Agriculture and climate change: Real problems, false solutions

Preliminary report by Grupo de Reflexion Rural, Biofuelwatch, EcoNexus and NOAH - Friends of the Earth Denmark

by Helena Paul, Stella Semino, Antje Lorch, Bente Hessellund Andersen, Susanne Gura & Almuth Ernsting

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Contact for the authors in Bonn:

Helena Paul: +49-176-77156622 h.paul@econexus.info

Almuth Ernsting: +44-7931-636337 almuth@ernsting.wanadoo.co.uk

Susanne Gura: +49-177-669 1400 gura@dinse.net

Content

Executive Summary

Industrial agriculture clearly causes climate change. But can changes in agriculture also help to mitigate the problems of climate change? Would carbon credits for agriculture promote such changes?

This report gives a brief overview on how current and proposed agricultural practices impact on climate changes, and how proposed measures for 'mitigation and adaptation' impact on agriculture. It focuses on forms of intensive, large-scale (or industrialized) agriculture. It looks at the main proposals in the negotiations for a post -2012 climate agreement. In the context of these negotiations, mitigation describes measures that deal with the causes of climate change, while adaptation encompasses measures to deal with the effects of climate change.

Industrial agriculture as currently practiced with monocultures and agrochemicals in a globalized production system, is a major contributor to climate change, causing emissions of greenhouse gases (GHG) through changes in land use and soil losses/degradation, through agricultural technologies and from livestocks. At the same time, climate change is already serious and likely to get worse, resulting in land loss and unpredictable changes of natural growing conditions.

Agricultural emissions and carbon credits

Yet in many quarters, including the United Nations Framework Convention on Climate Change (UNFCCC) itself, further intensification of industrial agriculture is proposed as a solution to the problems of climate change to which it has contributed in the first place, without the impact of agriculture on climate change being addressed. In the current negotiations for a new climate treaty that is supposed to follow the Kyoto Protocol in 2012, agricultural practices are proposed as a means for climate change mitigation and as part of carbon trading. A particular focus of discussion is the storage of CO_2 and other forms of carbon in the soil (soil carbon sequestration).

One question to address at the beginning is what **GHG emissions from agriculture** do we already have now? About 40% of the land is currently used as agricultural lands, i.e. cropland, managed grassland, permanent crops including agro-forestry. A third of the arable land is used for feed production. Over the last 40 years, 13 million hectare of land including 6 million ha forest land were converted to agriculture annually, leading to depletion of soil matter and GHG emissions from soils. At the same time the livestock industry for meat and dairy production emits methane and nitrous oxide.

Economic growth, industrialized farming systems, greater meat consumption, free trade policies, and biomass production have greatly contributed to this development. Future trends such as further intensified agriculture dependent on agrochemicals and irrigation, increased and intensified livestock production, increased production of agricultural products besides food and feed (biomass, agrofuels, bioplastics) to replace fossil fuel products will only increase this trend.

Free trade in agricultural products also plays a double role here because the import of animal feed and agricultural commodities allows the (richer) importing countries to understate their true emission figures since the emissions in the production country don't enter into the importing countries' calculations.

While CO_2 emissions *increased* ever since the Kyoto Protocol came into force in 2005, so has the trade in CO_2 equivalents emission reduction. In 2008, **carbon trading** increased by 83% in just one year to 4.9 million CO_2 equivalents (CO_2e), and the majority of proposals for a post 2012 climate change agreements aims at further increase, including through the heavily criticized Clean Development Mechanism (CDM).

Today agriculture - or rather agribusiness and plantation companies - benefits from about 10% of CDM credits, including livestock manure management, heat generation from palm oil and using agricultural residues from biomass. However, credits for carbon sequestration in soils have so far not been accepted under the UNFCCC. In the case of no-till monoculture as a form of sequestration, there is evidence that it rather harms than benefits the climate and the soil still could be tilled at any moment, emitting carbon again. And for biochar, there is no consistent information of its fate in soils while any black carbon getting airborne from biochar practices would seriously contribute to climate change.

The questions put before the negotiators includes what kind of agriculture would be likely to be funded through carbon trading? Would this necessarily be a sustainable form of agriculture? The list currently proposed by the UNFCCC includes a number of questionable practices that are likely to intensify industrial agriculture, such as for example agrofuel production, supporting them as climate friendly despite overwhelming and peer-reviewed evidence that they *accelerate* global warming. Non-industrial, biodiverse farming by small-scale farmers however is unlikely to benefit. The aim of protecting forests through REDD is already seriously undermined by the fact that the UNFCCC definition of ‘forests’ includes industrial tree and shrub plantations.

Proposals for soil carbon sequestration: Non-tillage and biochar

In **non-tillage agriculture** (NT or no-till), soil carbon emissions are meant to be reduced by not disturbing the soil through tillage. There are different forms of this practice, but the dominant method is to sow (or drill) the seeds into the residues for the previous crop, and to deal with weeds through the application of herbicides. Even though genetically modified (GM) crops were not explicitly developed for this purpose, they lend themselves to this practice. To date there are only estimates of how much carbon is sequestered in the soil in NT systems, and how this interacts with other factors, like soil respiration, N_2O emissions and de-nitrification. At the same time, experiences from existing, large scale NT agriculture show negative impacts on the environment and the climate.

In 2009 in Argentina, nearly 17 million hectares are cultivated with GM soya under NT, representing 20% of the total NT acreage worldwide. After more than 10 years of this practice, problems include such a heavy compaction of the soil that it fails to absorb water, herbicide resistant weeds, high use of agrochemicals with associated environmental problems, soil demineralisation and adverse effects on waters. It is still unclear to what degree the leaves left on the field at the end of the growing season contribute to nitrates in the soil, and how much phosphorus is effectively removed from the soil in form of the harvested soybeans.

Biochar is proposed as a new form of soil carbon sequestration in which fine-ground charcoal is applied to the soil. The type of carbon in this case is identical to 'black carbon', small particles known for its disastrous effects on climate change when airborne. The application of charcoal is known from some traditional agricultural practises where it has been part of biodiverse integrated farming methods, but the practices supported by the International Biochar Initiative (IBI) bear little resemblance to this. IBI argues that applying charcoal to soils would create a reliable and permanent carbon sink, and would mitigate climate change, as well as making soils more fertile and water retentive. However, even the studies of IBI members and supporters indicate high levels of uncertainty and counter-indications. In addition, proponents of biochar do not consider the direct and indirect impact of land-use changes required to grow enough biomass raw materials, or the impact of removing large quantities of of so-called residues from fields and forests. Biochar advocates describe the burning of biomass to produce charcoal (pyrolysis) as (close to) carbon neutral because GHG emissions during combustion are supposedly offset by new growth. This completely overlooks the impacts associated with the conversion or degradation of large areas of land necessary in this process, and thereby the destruction of existing ecosystems. Yet biochar is explicitly proposed for negotiations.

It is also unclear how long most black carbon will remain in the soil, how fast much of it will be degraded and turned into CO_2, and to what extent it can cause pre-existing organic carbon in the soil to be degraded and emitted as CO_2. Recent research shows that adding charcoal to soil sometimes even *increased* soil respiration and thus CO_2 emissions.

In addition to these unanswered questions about the effectiveness of biochar as carbon sequestration and its possible effects on soil fertility and soil respiration, a real danger lies in the actual application procedure of biochar. Laying charcoal near the soil surface may lead to erosion, oxidation and air borne particles. Airborne black carbon has a global warming impact 500-800 times greater than that of CO_2 over a century. Tilling it into the soil on the other hand can damage soil structures and cause break-down of pre-existing soil carbon.

Where should it all come from? GM crops and marginal lands

Proposals to use agricultural land for mitigation and adaptation, to produce biomass for biochar and agrofuels to replace fossil fuel production and to act as carbon sinks, have to deal with the problem that the industrial production plus food and feed already requires more agricultural land than available.

On the one hand, new **genetically modified (GM) crops** are proposed for higher yields through a number of new or enhanced traits (more yield; the ability to grow in different and/or hostile environments; changed composition to convert plants into raw materials more efficiently etc.). However, none of these crops, even if they could be developed, are likely to be available any time soon, and for a number of the promised GM traits, it becomes more and more questionable whether they can ever be achieved given the complexity of the genome and gene regulation. At the same time, despite adverse claims, the currently herbicide tolerant and insecticide producing GM crops, in general do not show yield increases. Especially the large-scale cultivation of herbicide tolerant GM crops (as for example described for Argentina) shows especially negative environmental and climatic impacts.

Climate change has intensified the need for abiotic stress tolerance in crops, but this does not mean we must develop stress tolerant GM crops. Abiotic stress tolerance can also be developed through conventional breeding or by using already adapted crop varieties.

Moreover, a focus of crop development on GM crops can cause high opportunity costs: money and time spent on technical developments for crops for the same agricultural model of intensive monocultures that are already now causing problems. GM crops are also fundamental to the development of the bioeconomy, whereby products from fossil oil deposits will be replaced by products derived from biomass. Growing the requisite amount of biomass has massive implications for land-use and climate change in future.

Besides increasing yields per hectare, another general proposal is to increase the acreage for agriculture by using so-called **'marginal' lands**. However, un-used land is rare. Instead much of it is common/communal land, collectively used by local people who might not have an individual land title, but who used it as vital resources for water, (additional) food, medicines and materials, and/or extensive grazing ground for livestock. What's seen as marginal land is often land used by 'marginalized people, by economically weaker parts of the communities. Such land is also important for biodiversity, water supplies, soil and ecosystem regeneration.

The omitted part of agriculture: livestock industry and feed production

Proposals to reduce emissions from agriculture often focus on plant production or soils, while livestock production is often omitted in spite of the fact that it accounts for important amounts of CO_2, NO_2, CH_4 and NH_3 emissions. Factory farms cause unsolved problems of water, soil and air pollution. Significant parts of agricultural land are used for feed production.

Industrial livestock production has moved away from multifunctional animals fed on locally produced roughage and nutrient rich waste from farms and households to genetically uniform breeding lines selected for high output that need standardized food, intensive veterinary care and controlled environments to avoid any infection. 'Compound feed' now competes with food production and is transported over long distances, causing negative climate impacts.

A drastic reduction of meat and milk consumption would therefore have a significant positive climate impact. It would also have a positive health impact on the world population since one billion people are obese - about as many people as are under-nourished. A change towards integrated, multifunctional systems and extensive grazing on grasslands can contribute to positive impacts of agriculture. Grassland and ruminating animals have evolved together. Extensive grazing should be supported to maintain grasslands as a major carbon sinks and as ecosystems.

However current proposals aim for even more intensified livestock production with animals bred for higher rates of feed conversion, in order to lower GHG emissions per product unit. However, such calculations are not relevant unless the *whole* life cycle including feed production is taken into account. The same goes for aquaculture systems where, for example, effects like cross-breeding of escaped salmon with wild salmon or deforestation to establish shrimp farms are not taken into account.

Other programmes aim at reducing the amount of GHG emitted by ruminant animals, but since methanogenes, the organisms digesting roughage in the rumen, belong to the least understood group of microorganisms, any project to change the enteric fermentations of cattle is a long way off.

Conclusions

Agriculture plays an important role in climate change, both as a contributor emitting GHGs and as a potential reducer of negative impacts. However, the current range of proposed technical solutions such as biochar, no-till agriculture with herbicide tolerant GM crops, the replacement of fossil energy products with agricultural (raw) products, the potential development of GM crops with completely new traits, and the wide spread use of industrial biomass processing biorefineries, as well as the increasing inclusion of these and more into carbon markets are a diversion from what is really required. In most cases the effectiveness and the possible negative impacts of the proposed measures are not yet assessed, and the plants are in the early stages of development. In general there simply is not enough land to account for the proposed projects, and the danger is that the option to gain carbon credits will put even more pressure on small-holders and marginalized people, living off so-called marginal land. The proposals, far from mitigating climate change, can be expected to seriously worsen it, and to also have a devastating impact on biodiversity.

But there are options for using agriculture to mitigate climate change: reversing intensive forms of agriculture, reducing reliance on agrochemicals and drastically reducing meat consumption. The challenge for a post-2012 climate treaty however is to withstand the lobbying of companies wanting to profit and take carbon credits from agricultural practices, and to properly stimulate change toward a sustainable and climate-friendly agriculture.

1. Introduction

This paper discusses some of the ways in which industrial agriculture is proposed to mitigate and promote adaptation to climate change in the UN Framework Convention on Climate Change (UNFCCC).

> In brief, *mitigation* deals with the causes of climate change, while *adaptation* tackles its effects. The Intergovernmental Panel on Climate Change (IPCC) defines mitigation as “an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases” and adaptation as “the adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.”[1]

Proposals for mitigation include the agricultural practise of non-tillage (no-till), the exploitation of biomass as bio- or agrofuels[2] and 'biochar' to counter climate change as well as the intensification of the livestock industry; adaptation on the other hand includes the development and cultivation of genetically modified (GM) 'climate ready' crops and the exploitation of so-called marginal land. This report will also discuss the likely consequences of including agriculture and soils in carbon trading.

Agriculture is a major contributor to climate change. In 2000, about 35% of greenhouse gas emissions came from non-energy emissions: 14% were nitrous oxide and methane from agriculture, 18% from land use change mainly from deforestation for agricultural purposes, plus additional large emissions from soil carbon losses, including peat degradation.[3] These figures do not include the energy footprint related to agricultural practice; for example the US food system accounts for some 17% of US energy consumption.[4]

At the same time, the impacts of climate change on agriculture are already serious. Seasons and weather are becoming increasingly unpredictable and extreme. This can lead to major losses as farmers no longer know what or when to plant. If climate change continues unabated, the increasing extremes could lead to the collapse of whole agricultural regions. Climate change also disrupts and alters pest and disease patterns, posing risks to agriculture everywhere.

Further intensification proposed

It is widely accepted that industrial agriculture has had destructive impacts on climate, ecosystems, soil, water and biodiversity resources, yet agriculture has hitherto been neglected in UNFCCC negotiations and in the government departments addressing climate change. However, in many quarters, including the United Nations Framework Convention on Climate Change (UNFCCC) itself, further intensification of industrial agriculture is now proposed as part of the solution to the problems of climate change to which it has contributed in the first place.[5] Intensive industrial monoculture production, for example, is proposed as a means to produce agrofuels and biochar on a massive scale as well as to develop a bioeconomy, in which fuels and industrial materials are produced from biomass instead of from fossil oil.

Agriculture for the climate market

Now, as negotiations begin for the new climate treaty to replace the 1997 Kyoto Protocol, proposals are being made to include agriculture as an eligible source for climate change mitigation, especially soil carbon sequestration. The International Food Policy Research Institute

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1 IPCC (2001): Climate Change 2001: Mitigation. Annex II Glossary. http://www.ipcc.ch/ipccreports/tar/wg3/454.htm

2 The use of crop plants as fuels is often described as “biofuel”. In this report we use the term “agrofuel” to describe them clearly as agricultural products. For details on the relationship between agrofuels and climat change se also Chapter 1 of “Agrofuels: Towards a reality check in nine key areas” by Ernsting et al. (2007): http://www.econexus.info

3 Stern N. (2006): Stern Review on the Economics of Climate Change. Executive Summary. HM treasury. http://www.hm-treasury.gov.uk/d/Executive_Summary.pdf and Annex 7.g: Emissions from agriculture sector http://www.hm-treasury.gov.uk/d/annex7g_agriculture.pdf. Greenhouse gas emissions 2000: energy emissions: power 24%, industry 14%, transport 14%, buildings 8%, other 5%; non-energy emissions: land use 18% , agriculture 14%, waste 3%.

4 Grain (2007): Stop the Agrofuel Craze. Seedling July 2007: 2-9; http://www.grain.org/seedling_files/seed-07-07-2-en.pdf

5 United Nations (2008): *Challenges and opportunities for mitigation in the agricultural sector UNFCCC: FCCC/TP/2008/8.*

(IFPRI) and FAO have both endorsed this.[6]

The FAO Assistant Director General Alexander Müller[7] even argued for an inclusion of soil carbon sequestration by stating that "*soil carbon sequestration, through which nearly 90% of agriculture's climate change mitigation potential could be realized, is outside the scope of the Clean Development Mechanism under the Kyoto Protocol*" but that carbon markets should be introduced to "*provide strong incentives for public and private carbon funds in developed countries to buy agriculture-related emission reductions from developing countries [...].*"[8]

In recent months, the United Nations Convention to Combat Desertification (UNCCD) followed by a number of African countries and Belize have begun to promote biochar for carbon sequestration and as a soil additive.[9] Biochar is basically charcoal, but - more importantly - it is also a by-product of methods currently explored to process biomass into so-called second generation agrofuels (see chapter 3.2).

We may therefore expect increasing calls for:

- agriculture to be included in negotiations of the new climate treaty to replace the 1997 Kyoto Protocol discussions in Copenhagen (like the suggestions by IFPRI and FAO);
- payment for environmental services (PES) for agriculture, to be funded mostly through carbon markets; and
- special emphasis on carbon sequestration in soil, including CDM status for biochar.

In this context the FAO sees the aforementioned 'agriculture-related emission reductions from developing countries' as a chance to "*provide important investments to spur rural development and sustainable agriculture in developing countries. Product standards and labels could be developed to certify the mitigation impact of agricultural goods.*"[10]

However we question his view that such trading systems are unequivocally positive. First of all, the measuring and certification of emissions reductions and the regulation of such markets will be a problem in itself. But more importantly, their existence will offer developed countries and their industries the opportunity to use offset programmes and similar mechanisms to avoid their obligation to reduce their own climate emissions. Trading services in agriculture will not address the fundamental problems of relying on a model of permanent economic growth on a planet of finite resources. Instead, having just experienced the impacts of a subprime property market, we now run the risk of building a subprime carbon market whose impacts could be far deadlier.[11] Furthermore, emissions trading hinders emission reduction and efficiency improvements.[12] But worst of all we are speeding up the destruction of the biodiversity and ecosystems that are crucial to any hope to stabilise climate, produce food and leave a habitable planet to future generations.

There are alternative models for the future of agriculture, but they are currently neglected in the UNFCCC process. They include biodiverse ecological agriculture and agroforestry, which can increase food production and reduce the climate footprint of agriculture, as well as playing a major role in ecosystem restoration and maintenance. Agriculture should be recognized more clearly as a multifunctional activity. It not only produces food, medicine, materials, fibres, etc, and can effectively recycle wastes into soil restoration, but also has many other roles. This includes protecting biodiversity, soils, water sources in tune with the local ecology (ecosystem functions) and has additional cultural, landscape, and well-being

6 Nelson G.C. (2009): Agriculture and climate change: An agenda for negotiation in Copenhagen. IFPRI, Focus 16. http://www.ifpri.org/2020/focus/focus16/Focus16_01.pdf ; FAO (2009): Climate change talks should include farmers. Press release, 2 April 2009. http://www.fao.org/news/story/en/item/11356/icode/

7 at the the climate negotiations in Bonn in April 2009

8 FAO (2009): Climate change talks should include farmers. Press release, 2 April 2009. http://www.fao.org/news/story/en/item/11356/icode/

9 UNCCD (2009): Submission by the United Nations Convention to Combat Desertification, 5th Session of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA 5), Bonn, Germany, 29 March – 8 April 2009; http://www.unccd.int/publicinfo/AWGLCA5/UNCCD_2nd_submission_land_soils_and_UNFCCC_process_05Feb.pdf African governments (2009): Submission of African Governments to the 5th Session of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA 5), Bonn, Germany, 29 March - April 2009 : The Gambia, Ghana, Lesotho, Mozambique, Niger, Senegal, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe; http://unfccc.int/files/kyoto_protocol/application/pdf/swazilandonbehalfof060209.pdf

10 FAO (2009): Climate change talks should include farmers. Press release, 2 April 2009. http://www.fao.org/news/story/en/item/11356/icode/

11 Friends of the Earth (2008): Subprime Carbon? Re-thinking the world's largest new derivatives market., Friends of the Earth, http://www.foe.org/subprime-carbon

12 EurActiv.com (2009): Carbon trading 'stifling EU energy-savings potential'. 22 April 2009. http://www.euractiv.com/en/energy-efficiency/carbon-trading-stifling-eu-energy-savings-potential/article-181502

values for people, over and above their need for nourishment. Finally, it is a repository for knowledge built up over generations that we lose at our peril.

Messages like these come for example from farmers themselves, such as in La Via Campesina's report on how small-scale sustainable farmers are cooling down the earth[13] or in Practical Action's forthcoming paper on biodiverse agriculture for a changing climate.[14]

Also the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) report,[15] written by 400 scientist in a cooperative process between a wide range of UN institutions and approved by 57 governments prior to publication notes:

> " A powerful tool for meeting development and sustainability goals resides in empowering farmers to innovatively manage soils, water, biological resources, pests, disease vectors, genetic diversity, and conserve natural resources in a culturally appropriate manner."[16]

Great caution is needed about adopting agriculture practices and techniques for climate change mitigation. Policy makers should not assume that solutions to climate change are necessarily technical. Many of them are social and cultural. We urgently need to shift our focus away from technology 'futures' promises to the readily available knowledge, experience and resourcefulness of local communities.

2. Carbon Trading Proposals for Agriculture

In 2008, 4.9 billion tonnes of carbon dioxide equivalent (CO_2e) emission reductions were traded on global carbon markets. Overall, carbon trading increased by 83% in just one year.[17] However, trading in emissions reductions does not imply emissions being reduced. Since the Kyoto Protocol came into force in 2005, global CO_2 emissions, including from fossil fuel burning and cement production, have been increasing. The growing carbon markets have not led to overall emission reductions in the industrialized nations which are committed to reducing their greenhouse gas emissions under the Kyoto Protocol, the so-called Annex 1 countries.[18] Instead, the world is now on course for the worst emissions scenario predicted by the Intergovernmental Panel on Climate Change (IPCC), or perhaps an even worse one.[19] Peter Atherton of Citigroup, strongly involved in carbon trading, described the world's biggest carbon market in 2007: "*The European Emissions Trading Scheme has done nothing to curb emissions… Have policy goals been achieved? Prices up, emissions up, profits up… so, not really.*"[20]

Nonetheless, the great majority of proposals for a post-2012 climate change agreement aim at a significant increase in carbon trading, including in the Clean Development Mechanism (CDM), administered by United Nations Framework Convention on Climate Change (UNFCCC). The CDM plays a crucial role within the carbon markets because CDM credits can be traded on other carbon markets, including the European Emissions Trading Scheme, which accounts for two thirds of all carbon trading. The only exception are CDM credits for "afforestation and reforestation" which cannot be traded under the European scheme.

The CDM has come under sustained criticism, amongst other issues, for funding projects which are not 'additional' and would have gone ahead anyway, for "being routinely abused by chemical, wind, gas and hydro companies who are claiming emission reduction credits for projects that should

13 Via Campesina (2007): Small scale sustainable farmers are cooling down the earth. Background paper; (accessed 20.5.2009) http://viacampesina.org/main_en/index.php?option=com_content&task=view&id=457&Itemid=37

14 Practial Action (forthcoming): *Biodiverse agriculture for a changing climate.*

15 Practical Action, GM Freeze and Friends of the Earth (2009): *ractical Action, GM Freeze and Friends of the Earth.* Special briefing

16 IAASTD (2009): *Summary for Decision Makers of the Global Report.* Island Press, Washington, USA. http://www.agassessment.org/docs/SR_Exec_Sum_280508_English.htm

17 environmetalleader.com (2009): Carbon market up 83% In 2008, value hits $125 billion. 14.1.2009; accessed 20.5.2009; www.environmentalleader.com/2009/01/14/carbon-market-up-83-in-2008-value-hits-125-billion/

18 Netherlands Environmental Assessment Agency (2008): Global CO2 emissions: increase continued in 2007. 13.6.2009, accessed 20.5.2009; www.pbl.nl/en/publications/2008/GlobalCO2emissionsthrough2007.html

19 International Scientific Congress Climate Change: Global Risks, Challenges & Decisions (2009): Key messages from the congres. 12.3.2009, accessed 20.5.2009; http://climatecongress.ku.dk/newsroom/congress_key_messages/

20 Citigroup Global Markets (2007), quoted in L. Lohmann in *Governance as Corruption,* presentation, Athens, November 2008; www.thecornerhouse.org.uk/pdf/document/ATHENS%2010.pdf

not qualify",[21] and for funding projects which *increase* greenhouse gas emissions, such as hydro dams.[22] Looking beyond these specific concerns, the principle of carbon-offsetting, which includes the CDM, is fundamentally flawed because any offset is used to licence fossil fuel buring elsewhere, thus permittting an overall increase in carbon dioxide concentrations. Despite this, many of the proposals made by Parties for a post-2012 climate change agreement entail a major expansion of the CDM and a weakening of existing safeguards, weak as they are at present. On the one hand, the CDM could cover new technologies, such as carbon capture and storage or nuclear power; on the other hand, the rules could be changed so that it could become easier for certain methdologies, and thus technologies, including biochar (see chapter 4) or no-till agriculture (see chapter 3) to be approved for funding. Furthermore, there are attempts to lift the current restriction for the proportion of CDM credits that can come from carbon sequestration (carbon storage).

At present, a maximum of 1% of CDM credits can come from sequestration in forests, whereby the term 'forest' includes tree and shrub plantations. As of 2008, such projects accounted for just 0.07% of CDM credits, but no CDM credits for carbon sequestration in soils are allowed. However, this is seen as key to including agriculture and agrocecological approaches as a carbon sink. Among others, the United Nations Convention to Combat Desertification (UNCCD) now calls to raise the 1% limit and to include soil carbon sequestration into the CDM.

There are three further proposals which would greatly increase carbon trading and erode or even abolish any rules which are supposed to link the CDM to emissions reductions. Agriculture is likely to be affected by each one of those proposals.

- **Sectoral Agreements** whereby emissions in Annex I countries could be offset against wider policies in a particular sector (such as agriculture) in a non-Annex I country,
- **Nationally Appropriate Mitigation Actions (NAMAs)** to which non-Annex I countries s (i.e. mainly developing countries) voluntarily agree and which could be funded through public funds as well as be used to offset Annex I countries emissions. As with Sectoral Agreements, these policies could be designed to result in a lower increase in emissions than forecast rather than in any emissions reductions.[23]
- **REDD-plus: REDD (Reducing Emissions from Deforestation and Degradation)** involves funding for reducing deforestation and degradation. The 'plus' refers to funding for forest conservation, sustainable forest management (a term routinely used for industrial logging) and for 'carbon stock enhancement', a term used for industrial tree plantations, which would probably come partly or in full through carbon trading.[24]

A further proposal would also boost carbon market funding for agriculture: it could become illegal for national regional emissions trading schemes to discriminate between different types of emissions reductions approved by UNFCCC. At the moment, the EU Emissions Trading Scheme excludes agriculture and forestry projects. If the EU was forced to include both, this could quickly direct large funding streams to agribusiness and plantation companies.

The role of agriculture in carbon trading today

Carbon trading has created windfall profits for power companies in Annex I countries, particularly in Europe, and for fossil fuel companies and other industries responsible for high levels of greenhouse gas emissions in non-Annex I countries. At present, around 6% of CDM funding goes to agricultural project and an additional significant amount to biomass energy projects.[25] Those credits include livestock manure management (including biogas from swine manure) heat generation from palm oil mill effluents, and the use of agricultural residues for biomass. There are big winners. For example, in 2007, 90% of all approved CDM projects in Malaysia benefited palm oil companies.[26] However,

21 Vidal J. (2008): *Billions wasted on UN climate programme.* The Guardian, 26.5.2008.

22 Langman J. (2008): *Generating Conflict.* Newsweek International, 13.9.2008

23 Reyes O. (2008): Ad Hoc Working Group on Kyoto Protocol update, aka how to expand carbon markets and count emissions increases as reductions. Carbon Trade Watch, 17.4.2009, accessed 20.5.209; http://www.carbontradewatch.org/index.php?option=com_content&task=view&id=261&Itemid=36

24 REDD-Monitor (without date): REDD: An introduction. accessed 20.5.2009; www.redd-monitor.org/redd-an-introduction/

25 Clean Development Mechanism – Appraisal of GHG standards and issues for agricultural mitigation, Neeta Hooda, UNFCCC Secretariat, presented at Conservation Agriculture Consultation, October 2008

26 Biofuelwatch (2007): South East Asia's peat fires and global warming. Factsheet 1, Biofuelwatch, 6.6.2007, http://www.biofuelwatch.org.uk/peatfiresbackground060607.pdf

large agribusiness firms like Monsanto have so far obtained very little funding through carbon markets and none through the CDM, despite a longstanding lobbying campaign for no-till GM monocultures to be classed as a way of sequestering carbon and reducing emissions. There is no CDM methodology for greenhouse gas reductions from agricultural methods such as no till, due to the high uncertainties, for example relating to carbon dioxide fluxes and nitrous oxide emissions linked to no-till monocultures. CDM credits for soil carbon sequestration from cropland or forest management were ruled out in 2003.[27] Only the Chicago Climate Exchange and a few carbon offsetting companies and schemes, such as C-Lock Technology Canada provide carbon credits for soil carbon sequestration.

Nor has the agrofuel industry profited from carbon trading as yet. So far, no CDM projects have been approved which use either biomass from crops and trees grown for this purpose, or vegetable oil other than waste vegetable oil. Nor do other carbon trading schemes appear to support agrofuels.

So far, only one larger carbon trading scheme, the Chicago Climate Exchange, has included agriculture and specifically no-till farming. In Saskatchewan, a pilot project was set up in 2005 which allowed trading in credits from no-till farming, but this was later abandoned. In Australia, Carbon Farmers have set up the Australian Soil Carbon Grower Register which assesses conditional carbon credits, however those are not being traded as yet and the Australian Government has so far been reluctant to give in to calls by the Opposition leader to set and meet a high climate target largely with biochar and other soil carbon sequestration methods.

Agribusiness hopes for a post-2012 Climate Agreement

In theory, the reasons against including soil carbon sequestration into the CDM remain. The UNFCCC Secretariat confirmed in a recent presentation that lack of permanence (for example because a change in agricultural practices could release the soil carbon), and a high level of uncertainty regarding emissions remain serious obstacles.[28] Including agricultural soil carbon sequestration schemes and methods such as no-till agriculture despite fundamental concerns would further undermine the credibility of a climate agreement. It would allow certain and irreversible emissions from fossil fuel burning to be offset against highly uncertain soil sequestration methods. In the case of no-till monocultures, not only is there strong evidence that they *harm* - rather than benefit - the climate, but also the land could be tilled at any time if agricultural practice required it. In the case of biochar, there is no consistent information about its fate in soils and one study which looks at black carbon from wildfires suggests that most of it could be lost within a few decades.

Nonetheless, agribusiness companies as well as biochar firms and advocates are optimistic about reaping a windfall from carbon trading. In the US, the 25x'25 Coalition has been instrumental in shaping the new administrations climate change policy. They comprise leading figures in the US soya and maize lobby, as well as forestry companies. Their aim is to see 25% of US primary energy by 2025 produced not from renewable energy in general but from “America’s farms, forests and ranches.”[29] According to the US Energy Information Administration, the proposed US climate change legislation will boost agrofuels and solid biomass to a far greater extent than wind or solar energy.[30] The 25x'25 Coalition lobbies not just for subsidies and targets for industrial bioenergy, but also for major carbon offsets from agriculture. They want major subsidies from carbon trading, but no limits to greenhouse gas emissions from the agricultural sector, i.e. no requirements to move away from greenhouse gas intensive practices and reduce emissions from agriculture overall. If was implemented then, they predict “the [US] agriculture and forestry sector could realise over $100 billion in additional annual gross revenue” - 50% of the total value of US agriculture.[31] The US government follows the agribusiness lobby by calling for major funding for agriculture through a post-2012 climate agreement.

27 see http://www.rubberboard.org.in/articles/websitematerialDDPhysiology.doc

28 UNFCCC Secretariat (2009): Technical paper: Challenges and opportunities for mitigation in the agricultural sector. presentation at AWG-LCA workshop on opportunities and challenges for mitigation in the agricultural sector , Bonn, 4.4.2009; http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/application/pdf/1_unfccc.pdf

29 25x'25 website; http://www.25x25.org

30 Energy Information Administration (2009): Impacts of a 25-percent renewable electricity standard as proposed in the American clean energy and security act discussion draft; http://www.eia.doe.gov/oiaf/servicerpt/acesa/index.html

31 25x'25 (2009): *Agriculture and Forestry in a Reduced Carbon Economy: Solutions from the Land. A Discussion Guide.* 1.4.2009

Which type of agricultural projects could be funded through carbon trading in future?

The UNFCCC Secretariat has summed up the types of agricultural activities which could in future be subsidised through carbon trading: No-till and low-till, agricultural set asides, agroforestry, conversion of cropland to grassland or forests, carbon sequestration in agro-ecosystems, agrofuels and other types of industrial bioenergy, peatland restoration, restoration of degraded land, water management, improved rice management, improved livestock and manure management, nitrification inhibitors and changes to the way in which synthetic fertilisers are used. The governments of eleven African countries, Belize, Micronesia as well as UNCCD have specifically called for the inclusion of biochar into the CDM.

Agrofuels and other bioenergy from monocultures, possibly combined with biochar, no-till GM plantations and the industrial livestock industry are likely to attract the bulk of future carbon credits for agriculture. This means that the majority of funding is likely to go into intensive industrial agriculture, which is a major cause of climate change. Agrofuels, for example, are likely to be supported as climate friendly despite overwhelming evidence, including in peer-reviewed studies, that they greatly *accelerate* global warming.[32]

Agricultural intensification, which is associated with high energy and fossil-fuel based fertiliser use, is seen as an effective means of reducing greenhouse, for example by the IPCC and by the UNFCCC Secretariat.[33] The idea is that raising per hectare yields will reduce pressure on ecosystems. However, the agrofuels and other types of bioenergy, supported by the same agencies, create an unlimited new market for agricultural and forest products. This dashes any hopes that higher yields will result in less pressure on ecosystems. Even if yields could be raised despite droughts and floods becoming more common due to climate change and despite soil and freshwater depletion, the increased demand for bioenergy will translate higher yields into higher profits and land prices and more incentives for companies to expand agriculture.

Some activities which clearly benefit climate and biodiversity have also been proposed for carbon trading, but will this be of benefit to them?

Example: US Carbon Trading versus the Conservation Reserve Programme

The 25x'25 Coalition describes the conversion of cropland to grassland, riparian buffers, forests and wetlands as a mitigation strategy which should benefit from carbon trading. This is undoubtedly a way of sequestering carbon and protecting biodiversity. In the US, the Conservation Reserve Programme (CRP) and the Wetlands Reserve Programme are highly successful environmental schemes. Farmers enter into agreements lasting 5-30 years whereby they receive government subsidies for taking land out of production and planting trees, shrubs or grass, or for restoring wetlands. According to US government system, the CRP sequesters 21 million tonnes of carbon every year and prevents 408 million tonnes of soil being eroded annually, as well as protecting a large number of plant and animal species and 40% of commercial beehives.[34] Yet those policies are being eroded fast, largely as a result of ethanol and agribusiness industry lobbying. The 25x'25 Coalition's proposal would replace a successful government-funded scheme with complex and competitive funding arrangements. Under a carbon trading scheme farmers would have to submit applications which are likely to be far more complicated for returns that are far less predictable than those from current government funding, since the price of a tonne of carbon continuously changes. Applications to the CDM or to national or regional carbon trading schemes invariably require the help of specialist consultants. Whereas funding for the Conservation Reserve Programme is ring-fenced, carbon credits for similar projects would not be. Farmers hoping to get help to restore wetlands or riparian buffers would

32 See for example: Fargione J. Hill J., Tilman D., Polasky St. & Hawthrone P (2008): *Land clearing and the biofuel carbon debt.* Science 319(5867): 1235-1238; and Searchinger *et al.* (2008): *Use of US cropland for biofuels increases greenhouse gases through emissions from land use change.* Science 319(5867): 1238-1240.

33 See UNFCCC (2009): Workshop on opportunities and challenges for mitigation in the agricultural sector. 4.4.2009; http://unfccc.int/meetings/ad_hoc_working_groups/lca/items/4815.php

34 FAPRI (2007): *Estimating Water Quality, Air Quality and Soil Carbon Benefits of the Conservation Reserve Program.* FAPRI-UMC Report #01-07; http://www.fsa.usda.gov/Internet/FSA_File/606586_hr.pdf

be competing with large agribusiness companies vying for money for no-till soya. This shows the difficulty of placing a successful government policy in competition with business interests.

REDD: Helping forests or plantation?

The Biochar Fund recently succeeded in obtaining funding from the Congo Basin Forest Fund for reducing deforestation in DR Congo.[35] The idea is that small farmers who currently practice slash-and-burn agriculture can permanently improve their crop yields with biochar and can therefore abandon their current practices. The funding was awarded despite the lack of evidence that biochar use will improve those farmers' crop yields at all, let alone over the long-term. However, biochar and different agricultural practices could yet be included into the REDD-plus Mechanism without having to reduce deforestation.

The definition of forests which applies to the CDM is wider than even that of the FAO or the Convention for Biological Diversity (CBD), which encompasses industrial tree plantations but excludes those agricultural production systems (such as oil palms) and plantations with an average height of less than five metres. In contrast, the UNFCCC definition includes any plantation of trees or shrubs of more than 2 metres in height, including by default GE trees. Planting oil palm or jatropha plantations could thus be classed as afforestation and reforestation, particularly if existing rules for such schemes are relaxed. The Mexican government already promotes palm oil and jatropha expansion and further intends to include its agricultural sector into its national REDD strategy.[36]

However, the US government even goes a step further: They call for a REDD-plus to cover not just forests but all types of land use. Countries should be able to choose which sector they wish to include first. Under a recent US REDD-plus proposal, it would become legitimate for countries to channel funding exclusively to agribusiness without any attempt to protect forests at all.[37] Support for integrating agriculture into REDD also comes from the International Agricultural and Food Trade Council, which includes Monsanto, Cargill, Syngenta, Unilever as well as WWF. They seek to combine this with an expansion of the CDM and the inclusion of agriculture into market-based Nationally Appropriate Mitigation Options.

Conclusions

In 2000, the US proposed that under the Kyoto Protocol an unlimited percentage of the total emission reductions would be allowed to come from tree plantations and agricultural practices instead of reducing emissions from other sources like industry and transport. This was rejected by the EU and many other Parties as undermining attempts to address the causes of climate change.

Proposals which are now being discussed for a post-2012 agreement resemble the former US proposal in that they would allow requirements for a large or even uncapped proportion of emission reductions to be met from questionable agricultural and forestry activities, without ending deforestation and other ecosystem destruction.

The market-based proposals relating to REDD-plus, "afforestation and reforestation", biochar and agriculture would greatly increase the classification of agricultural lands, forests and plantations as carbon sinks to offset emissions from fossil fuel burning. Furthermore, the possible inclusion of agriculture as well as industrial tree plantations into the REDD mechanism would undermine any REDD agreement and would allow countries to profit from tree or shrub plantations (such as jatropha) and, if the new US proposal is adopted, even from GM soya plantations regardless of continued deforestation. The aim of preserving forests would thus be completely undermined.

Proposals for the agricultural sector suggest that funding would primarily be channelled towards industrial agriculture, combined with agrofuel and agroenergy expansion. Non-industrial, biodiverse farming by small-scale farmers is unlikely to benefit. As Larry Lohmann from Corner House states: "The CDM's market structure biases it against small community based projects, which

35 Congo Basin Forest Fund (2009): Successful projects (2009) > Projects to receive funding from the CBFF. accessed 20.5.2009; http://www.cbf-fund.org/site_assets/downloads/pdf/projects_receiving_funding.pdf

36 Mexico (2009): Mexico: Challenges & Opportunities for mitigation in the agricultural sector. Presentation given at AWG-LCA 5th Session, Workshop on opportunities and challenges for mitigation in the agricultural sector, Bonn, Germany. 4.4.2009; http://unfccc.int/files/meetings/ad_hoc_working_groups/lca/application/pdf/8_mexico.pdf

37 United States of America (2009): United States Input to the Negotiating Text for Consideration at the 6th Session of the AWG-LCA. Copenhagen Decision Adopting the Implementing Agreement. submitted on 4.5.2009; http://unfccc.int/files/kyoto_protocol/application/pdf/usa040509.pdf

tend not to be able to afford the high transaction costs necessary for each scheme."[38] The high transaction costs, however, arises from the attempt to demonstrate climate benefits as well as the wider sustainability of projects. There is already strong evidence that CDM projects are routinely approved which do not meet these criteria. Further relaxing the requirements would make the system even more open for abuse. The bias towards large projects and companies rather than communities is thus inherent in the CDM.

Allowing general policy-based or sector-based carbon credits, rather than just project-based ones, would further uncouple so-called offsets from any emission reductions. There is even the possibility that rising emissions could be counted as emission reductions provided that they are lower than forecast. The proposed market-based policies are likely to benefit large-scale industrial agriculture, rather than non-industrial, integrated farming which has a high potential for mitigating climate change as well as preserving biodiversity. The emphasis on market based options is at the expense of successful government-funded and regulatory policies, such as the US Conservation Reserve Programme.

Proposals for agriculture to play as significant role in carbon trading and in wider market-based policies in a post-2012 climate agreement thus threaten to undermine any effective response to climate change.

On the one hand, the large-scale inclusion of agriculture and soil carbon sequestration into carbon trading as offsets will further weaken any incentives to reduce fossil fuel emissions. On the other hand the agricultural practices most likely to benefit are those such as no-till monocultures and biochar. Not only have those not been proven to benefit the climate but they are very likely to exacerbate climate change if used on a large scale. The main beneficiaries of the proposals are likely to be industries such as South America's soya industry or pulp and paper companies: industries which are likely to continue large-scale deforestation and other ecosystem destruction and thus faster climate change, for the pollution of air, soil and water, and for the displacement of indigenous peoples, small farmers and other communities.

38 Lohmann L. (2006): *Carbon Trading: A critical conversation on climate change, privatisation and power.* Development dialogue 48.

3. Offsets from no-till agriculture as a way to mitigate climate change

Non-tillage agriculture (NT), known also as no-till, conservation tillage or zero tillage, is a cultivation method which avoids soil disturbance. It is often also decribed as 'conservation tillage' even though this term is used to include some types of low tillage.[39] Modern development of NT began after ICI discovered the herbicide Paraquat in 1955. Before that, it was assumed that tillage was necessary to improve water infiltration and control weeds. This technique it is applied in eroded and depleted soils. One of its main advantages is that the soil is rarely exposed, helping to reduce the potential for erosion and evaporation. NT is said to improve the soil-aggregate formation, its microbial activity as well as water infiltration and storage.

In NT the new crop is sown into the residues of the previous crop. NT is employed in chemical agriculture which includes herbicide tolerant genetically modified (GM) crops. Unlike conventional tillage, which controls weed growth by ploughing and cultivating, NT agriculture uses herbicides to kill weeds and the remains of the previous crop.[40] NT was not developed for GM systems but lends itself for herbicide tolerant crop production, large machines, one-pass of the tractor, hence NT is massively embraced for GM.

Soils are among our most precious common assets. Once degraded, they are difficult to restore. They are complex structures where a large diversity of organisms live together with organic and non-organic matter. Land and soils have many functions, for ecosystems as well a human societies, and any increase of the carbon sink function must not disturb other functions.

This chapter deals with the climate and environmental aspects of NT agriculture employed for the cultivation of herbicide tolerant GM crops. It first discusses the claims related to climate mitigation and calls for granting offsets for NT agriculture and then illustrates how the agricultural system functions by presenting Argentina as case study, focusing on the environmental impacts of GM NT soybean production.

39 Harbinson R. (2001): *Conservation tillage and climate change*. Biotechnology and Development Monitor 46: 12-17.

40 A form of NT weed control is also used in organic agriculture. However, it is not used extensively, because it involves considerable work and because usually the cover crop residue is not able to smother weeds effectively.

3.1 The claim: No-till can reduced CO_2 in the atmosphere through storage in soil sinks

The International Panel for Climate Change (IPCC) 2006 Greenhouse Gas Inventory Guidelines suggest that conversion from conventional tillage (CT) to NT systems leads to a 10% increase in the estimated sequestration of carbon in the soil.[41] However, the IPCC's more recent Assessment Report 4 stresses uncertainty:

> "Since soil disturbance tends to stimulate soil carbon losses through enhanced decomposition and erosion, reduced- or no-till agriculture often results in soil carbon gain, but not always. Adopting reduced- or no-till may also affect N2O, emissions but the net effects are inconsistent and not well-quantified globally."[42]

There is little understanding of how tillage controls soil respiration in relation to N_2O emissions and de-nitrification. Higher CO_2 and N_2O fluxes were registered in NT soil than in CT soil irrespective of nitrogen source and soil moisture content.[43]

Furthermore new studies have cast doubt on the carbon sequestration claims.[44] For example, a review of studies that examined carbon sequestration in NT systems found that the sampling protocol produced biased results. In the majority of the studies Baker *et al.*[45] reviewed, soils were only sampled to a depth of 30 cm or less. The few studies that sampled at deeper levels found that NT showed no consistent build up of soil organic carbon. Conversely studies that have involved deeper sampling generally show no carbon sequestration advantage for conservation tillage, and in fact often show more carbon in conventionally tilled systems.

John M. Baker, research leader at the USDA Agricultural Research Service, Soil and Water Management Unit, concluded in his 2006 study on non-tillage and carbon sequestration that the evidence for increased carbon sequestration in NT systems is not compelling.

> "It is premature to predict the C sequestration potential of agricultural systems on the basis of projected changes in tillage practices, or to stimulate such changes with policies or market instruments designed to sequester C. The risk to the scientific community is a loss of credibility that may make it more difficult to foster adoption of other land use and management practices that demonstrably mitigate rising atmospheric concentrations of greenhouse gases."[46]

FAO and the Conservation Technology Information Center call for carbon offsets from no-till or conservation agriculture

In August 2008, FAO made a submission to the UNFCCC to propose a number of practices to reduce the rate of CO_2 released through soil respiration and to increase soil carbon sequestration, including conservation tillage (NT).[47] In October 2008 this was followed by the publication of a briefing titled "Framework for Valuing Soil Carbon as a Critical Ecosystem Service" by FAO and the Conservation Technology Information Center (CTIC). In this, the two institutions called for a wider adoption of conservation agricultural systems, and recommend the inclusion of carbon offsets from conservation agriculture.[48]

The biotech industry is well represented at the CTIC board of directors: Monsanto, Syngenta America and Crop Life America are occupying

41 with a 5% uncertainty factor

42 Smith P. et al. (2007): Agriculture. In: IPCC (eds.): Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Chapter 8. http://www.ipcc.ch/ipccreports/ar4-wg3.htm

43 Liu X.J., Mosier A.R., Halvorson A.D., Reule C.A. & Zhang F. (2007): *Dinitrogen and N_2O emission in arable soils: Effect of tillage, N source and soil moisture.* Journal of Soil Biology and Biochemistry 39: 2362-2370.

44 Yang X.M., Drury C.F., Wander M.M. & Kay B.D. (2008): *Evaluating the effect of tillage on carbon sequestration using the minimum detectable difference concept.* Pedosphere 18: 421-430.
Franzluebbers A.J. & Studemann J.A. (2009): *Soil-profile organic carbon and total nitrogen during 12 years of pasture management in the Southern Piedmont USA.* Agriculture, Ecosystems and Environment 129: 28-36.

45 Baker J.M., Ochsner T.E., Venterea R.T. & Griffis T.J. (2007): *Tillage and soil carbon sequestration – what do we really know?* Agriculture, Ecosystems and Environment 118: 1-5.

46 Baker *et al.* 2007

47 FAO (2008): *Submission by Food and Agriculture Organization of the United Nations, 3rd Session of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA3), Accra, 21-27 August 2008.* accessed 26.5.2009; http://unfccc.int/resource/docs/2008/smsn/igo/010.pdf

48 FAO (2008): Soil Carbon Sequestration In Conservation Agriculture. A Framework for Valuing Soil Carbon as a Critical Ecosystem. Summary document derived from the Conservation Agriculture Carbon Offset Consultation, West Lafayette, USA, 28-30.10.2008;
http://www.fao.org/ag/ca/doc/CA_SSC_Overview.pdf

seats. This fact endorses the conclusion that the FAO-CTIC call for agricultural offsets aims mainly to favour GM crops.

3.2 Argentina soils as an example GM no-till agriculture

Argentina has at present (2009) nearly 17 million hectares cultivated with GM soya under no-till systems. This represents 20% of the total acreage under no-till practice worldwide.[49]

Due to the increased availability of seeds and technology and due to a lower price for agrochemicals, GM agriculture was adopted in Argentina in the 1990s. The NT system was perceived as a solution to the soil degradation present in the Pampas region.[50] At that time, NT was mainly known for the conservation of organic matter and better water utilization.

However, after more than ten years of using NT for the cultivation of mainly GM soya,[51] profound negative environmental impacts are occurring. The use of pesticides induces resistance in weeds, leading to an increase in the quantity and variety of pesticides used. Soil fertility is declining due to intense production, and soil demineralisation is addressed by the use of synthetic fertilisers, whose production is energy intensive and whose use generates emissions of N_2O. The large quantity of chemicals, sprayed by terrestrial and aerial means, has negative impacts on biodiversity, water, soil, human and animal health. Furthermore, the adaptation of NT methods have been directly linked to greater deforestation in the seasonally dry forests in the north-west and thus to accelerated regional and global climate change.[52]

GM soya cultivation as carbon sinks and the IPCC agenda

The 1997, the Argentinean National inventory report for the UNFCCC acknowledged the soils under no-till GM soya fields as possible carbon sinks. In this report the no-till producers association AAPRESID[53] was the UNFCCC inventory rapporteur for the emissions for the change for the use of land.[54]

According to the official inventory “the use of conservation tillage systems, especially non-tillage, can increase the amount of organic matter in soil and in turn reduce CO_2 emissions, by sequestering approximately 4.9 million tonnes of C per year from the different agricultural regions of Argentina.”

Argentina has been asking the UNFCCC since 1998 for the introduction of no-till agriculture in the carbon market “as it is for the country interest as world-wide leader of NT”[55] - at least according to Hernan Carlino, Argentinean member of the UNFCCC Executive Board Committee of the Clean Development Mechanism (CDM) and until recently chairman of the CDM Accreditation Panel.

NT environmental impacts

Residues from soybean under no-tillage: To date, research on what occurs during soy plant defoliation is still lacking. In autumn, the leaves are left on the field, just at the time of major rains, where they decompose very quickly, bringing the nitrates to the soils and presumable being converted to N2O fluxes. In 2004, the Second National Communication on greenhouse gas emissions from agricultural activities acknowledged that “it is assumed that the agricultural residues are buried, however conclusive information still does

49 AAPRESID (2008): Siembra directa, con visión holística. 17.1.2008; accessed on 18.5.2009. http://www.concienciarural.com.ar/articulos/agricultura/siembra-directa-con-vision-holistica/art283.aspx

50 Casas R. (2003): Sustentabilidad de la agricultura en la región pampeana. Clima y Agua, Castelar. Instituto Nacional de Tecnología Agropecuaria; http://www.inta.gov.ar/balcarce/info/documentos/recnat/suelos/casas.htm

51 The lack of rotations in the Argentinean soya region it is mainly due to two factors: (a) high international demand and the comparative greater profits from soya, and (b) productive lands are rented to exogenous companies, who are not looking at soil as a resource to preserve.

52 Grau H.R., Gasparri N.I. & Aide T.M. (2005): Agriculture expansion and deforestation in seasonally dry forests of north-west Argentina. Environmental Conservation 32: 140-148.

53 Aapressid was created in 1988, after Monsanto had paid for all the start-up costs, Ekboir J. & Parellada G. (2002): Public-Private Interactions and technology policy in innovation processes for zero tillage in Argentina. In Byerlee D. & Echeverria (eds.): Agricultural Research Policy in an Era of Privatization, CAB International; http://www.cababstractsplus.org/fts/Uploads/PDF/20023109946.pdf

54 Ministerio de desarrollo social y medio ambiente Secretaria de Desarrollo Sustentable ypolitica ambiental (1999): Inventario de Emisiones de Gases de Efecto Invernadero de la Republica Argentina. Proyecto Metas de Emision Arg/99/003-PNUD-SRNyDS; http://www.medioambiente.gov.ar/archivos/web/UCC/File/inventario%20de%20gases%20en%20la%20argentina%201997.pdf

55 clarin.com (2005): El agro juega limpio. Clarin, 25.6.2005; http://www.clarin.com/suplementos/rural/2005/06/25/r-00901.htm

not exist about the possible emissions from [then] 14 million hectares under no-tillage."[56]

Soil compaction: Soil compaction in the Pampas region of Argentina is widespread and severe due to the lack of turning/tilling of the soil, continuous use over time, and the use of heavy equipment during seeding and harvest; all of which are associated with NT agriculture.[57] Compaction has adverse effects on a number of soil functions. With both increased water logging and poor aeration, soil compaction has a detrimental effect on the size and diversity of soil organism, and incidence and increase of crop pests and diseases.[58]

After years of intensive production of soybeans the compacted soil is left with a reduced capacity to absorb water from the surface; increased runoff has led to river flooding and reduced the capacity of plantations to resist periods of drought. In the past decade, Argentinean agricultural regions dedicated to the cultivation of soybean have suffered serious flooding, and it has been suggested that soybean cultivation and deforestation have contributed to these events.[59,60]

Soybean is produced mainly as a monoculture on 49% of the total cultivated area while 30.6% is rotated with wheat. To a much lesser extent soya is rotated with maize (corn) or sunflower.[61] The root systems of both crops are short (approximately 1.5 metres) and therefore incapable of penetrating deep enough into the soil to aerate the soil, lift nutrients and water from deeper horizons, and to improve fertility through N fixing.[62]

Research in the Argentinian Pampas in 2006 demonstrates that higher N_2O emissions may be attributed to greater water content in the soil, because de-nitrification is more intense as water-filled pore space increases. The study suggests that higher N_2O emissions in NT managed agricultural systems of the humid portion of the Pampas might counteract carbon sequestration within several decades.[63]

Agrochemical use: The intense production of soya is dependent on the use of agrochemicals (mainly glyphosate for the herbicide tolerant soya), which is associated with negative environmental impacts, including increased resistance to pesticides, which in turn leads to an increase in the quantity and types of pesticide used. As mentioned, pesticides use is also associated soil compaction and lately to climate change events like drought.[64] The prevalence of GM soya varieties also provokes changes in weed communities. These changes are not only observed in the quantity of weeds, but also in the appearance of weeds which were common in these areas before.[65,66]

The increase in GM soya cultivation has been the key driver of increase in agrochemical use in Argentina.[67] The herbicide glyphosate (GLY) has a

56 Taboada M.A. (2004): Inventario de gases efecto invernadero del sector agricola Argentino. Presentation at: II taller sobre la 2da comunicacion de cambio climatico, 29.11.2004; http://www.fundacionbariloche.org.ar/presentaciones/Segundo%20taller/Agricultura%20-%20Agro.ppt#1

57 Gerster G., Bacigaluppo S., De Battista J. & Cerana J. (2008): Distribución de la Compactación en el Perfil del Suelo utilizando diferentes Neumáticos. Consecuencias sobre el Enraizamiento del Cultivo de Soja. Instituto Nacional de Tecnologia Agropecuaria, Econoagro; http://www.econoagro.com:80/verArticulo.php?contenidoID=646

58 Ellis S. & Mellor A. (1995): *Soils and environment.* Routledge, London, UK: 254-256.

59 Marraro F. (2004): El problema de la expansión agrícola siembra soja y cosecharas inundados. Fundacion Proteger; http://www.proteger.org.ar/doc222.html.

60 La Capital (2001): Inundaciones ¿La Venganza Del Suelo? La capital, 24.11.2001; http://www.barrameda.com.ar/noticias/cambcl02.htm

61 Panichelli L., Dauriat A. & Gnansounou E. (2008): Life cycle assessment of soybean-based biodiesel in Argentina for export". The International Journal of Life Cycle Assessment 14: 144-159; http://www.springerlink.com/content/gq31272407530111

62 ConCiencia (2005): ¿Quien se acuerda del suelo? Universidad Nacional del Litoral, Santa Fe, Argentina, ConCiencia Nro.13, 4.2.2005; http://www.rel-uita.org/agricultura/suelo.htm

63 Steinbach H.S. & Alvarez R. (2006): *Changes in soil Organic carbon contents and N_2O emissions after introduction of no-till in Pampean agroecosystems*. Journal of Environmental Quality 35: 3-13

64 Prensa Fauba (2009): Sopresiva epidemia de la mancha ojo de rana en soja. 3.3.2009, accessed 23.5.2009; http://agroar.info/sorpresiva-epidemia-de-la-mancha-ojo-de-rana-en-soja.html

65 Faccini D. (2004): Los cambios tecnológicos y las nuevas especies de malezas en soja. Agromensaje Nº 4 de la Facultad de Ciencias Agrarias de Rosario; http://www.produccionbovina.com/produccion_y_manejo_pasturas/pasturas_combate_de_plagas_y_malezas/30-cambios_tecnologicos_y_nuevas%20especies_de_malezas_en_soja.htm

66 Tuesca D., Niesemsohn L. & Papa J. (2007): Para estar alerta: el sorgo de alepo resistente al glifosato INTA EEA Oliveros. http://www.inta.gov.ar/oliveros/info/documentos/soja/soja_malezas1.pdf

67 Bártoli M. (2007): Atentos y en guardia ante la roya. E-campo, 22.2.2007; http://www.e-campo.com/?event=news.display&id=E96C178E-188B-7C0FF222D0F67

70% share of the trade in agrochemicals, followed by insecticides (17.2%), fungicides (6.4%) and seed treatment fungicides (4%). Deleterious effects of glyphosate and chlorpyrifos (CPF) formulations when applied at the nominal concentrations recommended for soya crops have been identified for example for earthworms who avoid soils treated with glyphosate and show reduced cocoon viability, or significantly increased DNA damage in earthworms exposed to CPF treated soils.[68]

Soil Demineralisation: Contrarily to the assumption that soya is a nitrogen fixing plant that improves the soil nitrogen levels, in the Argentinean Pampas region continued increases in soya yields are followed by steep declines in soil nitrogen (N), phosphorous (P), potassium (K) and sulphur (S). Nitrogen deficiencies are especially high, despite the ability of soybeans to fix nitrogen biologically.[69] Soya produces the largest imbalance of nitrogen among crops, due to the high percentage of protein in the beans and the low input of nitrogen fertilizer.

Phosphorous nitrogen: Biological nitrogen is estimated to meet 30-40% of the needs of the GM Argentinean soybean crop. Therefore, the decline in soil fertility is causing concern amongst researchers about the long-term physical, ecological and economic sustainability of the region. It is estimated that these losses in soil fertility will continue for the next 15 years due to growing demand for oilseed crops. As a result, increased fertiliser use is required and more rotations are advised.

Fertilization: Within the agronomic activity, the application of fertilisers is identified by the IPCC as one of the principal causes of global warming. For soya, application rates of 30-120 kg/ha are are recommended for the two important nitrogen-containing fertilizers di-ammonium phosphate (DAP, $(NH_4)_2HPO_4$) and mono-ammonium phosphate (MAP, $NH_4H_2PO_4$).[70,71] Within the NT system, when rotation occurred, the crops which are following the soya production, required high inputs of N fertilizers. In 2007, a total of 3.69 million tonnes of fertilisers were sold. Of these, nitrogenised fertilisers accounted for 1.73 million tonnes, with phosphate fertilisers accounting for 1.58 million tonnes.[72]

Water quality: An Argentinean study on the effects of glyphosate on freshwater observed that changes in the structure of the microbial assemblages are more consistent with a direct toxicological effect of glyphosate rather than an indirect effect mediated by phosphorus enrichment. The researchers expressed concern that current agricultural practices, which rely heavily upon continuous additions of glyphosate, may alter the structure and function of many natural aquatic environments.[73]

Ground water contamination: The Argentina Agropecuarian Technological National Institute (INTA), recognises that no-till in the Pampas is a cause in the decline in organic matter and pH, which is leading to an important decline of the ability of the soil surface property to attenuate contaminants. This means that soils are losing their natural capacity immobilize heavy metals and micronutrients (nitrogen and phosphorus) which are steadily polluting the groundwater.[74]

Conclusion

The capacity to sequestrate carbon in soil under no-till agriculture is not conclusively proven and comparison with other management systems need to be made. The fact that FAO calls for offsets from the “conservationist/NT agriculture” together with the biotech industry shows vested interests which are playing against the independence required from an UN institution dealing, in this case, with one of the most precious common goods that this civilisation and the planet it self has the: soil.

Argentina is presented as a paradigm of intensive GM no-till agriculture where the ecosystem is seriously affected by the soya cultivation. Soil demineralisation and water pollution are registered and possibly widespread across the soya regions.

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68 Casabé N. *et al.* (2007): *Ecotoxicological Assessment of the Effects of Glyphosate and Chlorpyrifos in an Argentine Soya Field.* Journal Soils Sediments 7: 232-239.

69 Austin A.T., Piñeiro G. & Gonzalez-Polo M. (2006): *More is less: agricultural impacts on the N cycle in Argentina.* Biogeochemistry 79: 45-60.

70 Forjan H.J., Zamora M., Bergh R., Manso M.L., Seghezzo M.L. & Molfese E.R. (2006): T25 - Impacto de la inclusion de soja en secuencias agricolas del sur bonaerense: El balance de nutrientes. Chacra experimental integrada Barrow, Tecnología de Cultivo: 561-565; http://www.acsoja.org.ar/mercosoja2006/trabajos_pdf/T152.pdf

71 SAGPyA (Secretaría de Agricultura, Ganadería, Pesca y Alimentos) (2005), quoted in Forjan et al. 2006.

72 CASAFE (2007): Cámara de Sanitarios Agropecuarios y Fertilizantes, Estadísticas del Mercado de Fertilizantes en Argentina 1980-2007. http://www.casafe.org.ar/mediciondemercado.html

73 Perez *et al.* (2007): *Effects of the herbicide Roundup on freshwater microbial communities: a Mesocosm study.* Ecological Applications 17: 2310-2322.

74 InTA (2008): *Ni tan culpable el campo, ni tan inocente el poblados.* http://www.inta.gov.ar/pergamino/info/prensa/2008/cal_agua_080114.htm

The adverse impact of the no-till system is also evident in soil compaction which has a direct impact on the proliferation weed shifts and emergence of new diseases. pesticides contribute to loss of soil biota. If GM/NT agriculture is encouraged by Carbon Credit systems, then the scenario of un-sustainability of the rural landscapes will be of widespread havoc.

In brief there are too many negative impacts and too few proven benefits. In the short term it appears to simplify agriculture, but in the long term it could have serious negative impacts on both climate and agriculture.

4. Biochar: What can we expect from future carbon credits for using charcoal in soil?[75]

Biochar is a term coined by Peter Read of the International Biochar Initiative to describe fine-ground charcoal when its applied to soil. Charcoal generally is a byproduct of pyrolysis although research programmes are producing biochar by steam-heating biomass under high pressure (hydrothermal carbonisation). The type of carbon contained in biochar is **black carbon**.

Biomass pyrolysis is a type of bioenergy production in which biomass is exposed to high temperatures for short periods, with little or no oxygen. Besides biochar, this produces syngas, which can be used to replace natural gas, bio-oil, which can be used as a fuel for heating or ships, and which can also be refined into road transport or possibly aviation fuel. Pyrolysis can be done in large plants or small kilns or stoves.

Thirteen governments as well as the United Nations Convention to Combat Desertification (UNCCD) are formally calling for ‘biochar’ to play a significant role in a post-2012 climate change agreement and in carbon trading. They support claims by the International Biochar Initiative (IBI), a lobby organisation made up largely of biochar entrepreneurs as well as scientists, many of them with close industry links.[76] The IBI regularly lobbies delegates at UNFCCC meetings.

The IBI argues that applying charcoal to soil creates a reliable and permanent 'carbon sink' and mitigates climate change. It also argues that biochar makes soils more fertile and retains more water in soil, thus helping farmers adapt to climate change. However the science, including studies by leading IBI members themselves, points to high levels of uncertainty regarding all those claims. Soil science studies only look at the micro level, i.e. at what happens when biochar is applied to laboratory containers of soil or used on a small field. They do not consider the direct and indirect impacts of land-use change nor, at the impact of removing large quantities of so-called residues from fields and forests that would occur with large scale production systems. The quantities of biochar proposed for mitigating climate change would require more than 500 million hectares of additional plantations.[77]

What is the basis for claims that charcoal in soil is (part of) the solution to climate change and soil degradation?

Biochar lobbyists describe bioenergy with biochar production as 'carbon-negative.' This is based on a belief that biomass burning is carbon neutral or close to it, i.e. that it results in no significant greenhouse gas emissions since emissions during combustion are supposedly offset by new growth. Such a belief ignores the wider level impacts associated with the conversion of large areas of land and thus, directly or indirectly, the destruction of ecosystems which are essential for regulating the climate. Where “wastes and residues” are used, the impacts on climate and ecosystems of removing these crucial amounts of organic matter from soils are ignored, even though there is little 'waste' available for biochar anyway. Given the climate impacts of ecosystems conversion and forest and soil degradation, any large scale demand for biomass cannot be reasonably considered carbon neutral. Biochar advocates, however, tend to ignore this and further claim that the carbon contained in biochar will permanently remain in soils and that the technology can therefore be considered carbon negative because it would sink CO_2 from the atmosphere. Both the carbon neutral and the carbon negative assumptions are highly dubious.

The claims made by biochar advocates are to a large extent based on Terra Preta: highly fertile soils rich in black carbon, i.e. the type of carbon found in charcoal. These soils were created by indigenous farmers in Central Amazonia between

75 This chapter is based on the briefing paper: Ernsting A. & Smolker R. (2009): Biochar for Climate Change Mitigation: Fact or Fiction? Biofuelwatch; http://www.biofuelwatch.org.uk/docs/biocharbriefing.pdf

76 For membership of the IBI Board and Science Advisory Committee see http://www.biochar-international.org/abouttheibi/ibigovernance.html

77 Ernsting A. & Rughani D. (2008): *Climate Geo-engineering with ‘Carbon Negative’ Bioenergy* . Biofuelwatch. http://www.biofuelwatch.org.uk/docs/cnbe/cnbe.html?

500 and 4500 years ago who applied a large variety of biomass residues, including compost, river sediments, manure, fish bones and turtle shells as well as charcoal to their soils.[78] The charcoal has been shown to interact with fungi which help to maintain soil fertility over long periods.

Charcoal residues from wildfires and other sources have been found in soils which date back thousands of years, for example in the North American prairies, in Germany and Australia. It is therefore certain that some carbon in charcoal can - under certain circumstances that we do not yet understand - be retained in soils for thousands of years. Eventually however, it will be released as CO_2 and warm the atmosphere. The fact that some carbon from charcoal remains in the soil however, does not mean all or even most of it will.

Most of the studies on which claims about the properties of biochar are based, have been done in laboratories or greenhouses, some of them with sterile soils. There are very few field studies and only one peer-reviewed field experiment which looks at (short-term) impacts on soil fertility and soil carbon.[79] This still remains the case seven years after the first biochar company, Eprida, was founded. By analogy, this would be like releasing a new pharmaceutical product without clinical testing.

What is known about the impact of charcoal on soil fertility and carbon sequestration?

While carbon in charcoal can remain in soil for long periods, it can also be lost within decades, a few years, or even faster. Soil scientist consider black carbon from fires to be identical with or at least comparable to black carbon in biochar. Black carbon can be degraded and turned into CO_2 either through chemical processes or by microbes, and some types of carbon within charcoal are degraded far more easily than others.[80] Johannes Lehmann, Chair of the IBI Board, claims that only 1-20% of the carbon in charcoal will be lost this way in the short term and that the remainder will stay in the soil for thousands of years.[81] Yet, one study about the fate of black carbon from vegetation burning in Western Kenya suggests that 72% of the carbon was lost within 20-30 years.[82] Furthermore, in a recent (unpublished) study[83] researchers were unable to show that soil in old forests which have burned regularly over centuries hold more black carbon than soils from young forests which have not experienced repeated burning. The authors speculate that the black carbon could have oxidised (and thus entered the atmosphere as CO_2) during subsequent fires, or alternatively could have been distributed more widely instead of having been lost from the soil. An open question is also how biochar has different impacts in different soil types.

There is some evidence that the types of carbon in charcoal which degrade fastest might be those which can increase plant yields in the short term when used together with fertilisers.[84] In other words: there could be a trade-off between biochar which can raise soil fertility and biochar which can sequester carbon although the lack of field studies makes it impossible to be certain. Moreover, soil microbes have been found which can metabolise black carbon and thus turn it into CO_2.[85] Conceivably, if biochar was applied to large areas of land, these microbes might multiply and break down black carbon more easily than it currently occurs; others might adapt.

Another question is whether adding biochar to soil can cause pre-existing soil organic carbon to be degraded and emitted as carbon dioxide. This possibility was suggested by a study in which charcoal in mesh bags was placed into boreal forest soils and significant amounts of carbon were lost which the authors concluded must have been soil organic carbon. They suggest that the biochar would have stimulated greater microbial activity

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78 For more information see FAO Terra Preta –Amazonian Dark Earths (Brazil); http://www.fao.org/nr/giahs/other-systems/other/america/terra-preta/detailed-information2/en/

79 Lehmann *et al.* (2003): *Nutrient availability and leaching in an archaeological Anthrosol and a Ferralsol of the Central Amazon basin: fertilizer, manure and charcoal amendments.* Plant and Soil 249: 343-357; and Steiner *et al.* (2007): *Long term effects of manure, charcoal and mineral fertilization on crop production and fertility on a highly weathered Central Amazonian upland soil.* Plant and Soil 291:275–290; based on the same field experiment near Manaus.

80 Cheng C., Lehmann J.C., Thies J.E., Burton S.D. & Engelhard M.H. (2006): *Oxidation of black carbon by biotic and abiotic processes,* Organic Geochemistry 37:1477-1488.

81 Lehmann et al. (2008): Stability of black carbon/biochar. presentation at SSSA Conference, October 2008; http://www.biochar-international.org/sssa2008presentations.html

82 Nguyen *et al.* (2003): *Long-term black carbon dynamics in cultivated soil.* Biogeochemistry 89: 295-308.

83 Lorenz *et al.* (2008): *Black carbon in seasonally dry forests of Costa Rica.* presentation, see footnote 81.

84 Novak *et al.* (2008) *Influence of pecan-derived biochar on chemical properties of a Norfolk loamy sand soil.* presentation, see footnote 81

85 Hammer U., Marschner B., Brodowski S. & Ameung, W. (2004): *Interactive priming of black carbon and glucose mineralisation.* Organic Geochemistry 35: 823-830.

which would have degraded soil organic carbon and have caused it to be emitted as carbon dioxide.[86]

This is further supported by a laboratory study by Rogovska et al. (2008) which showed that adding charcoal to soil increased soil respiration and thus carbon dioxide emissions.[87] The authors hypothesized that this effect would normally be offset by greater plant growth adding new carbon to soils; however during the study no plants were grown. Initial results from a Danish study also suggest that charcoal addition leads to greater losses of existing soil organic carbon.[88]

Although some studies suggest that charcoal additions can reduce nitrous oxide emissions, the evidence on this is neither conclusive nor consistent.[89]

Is charcoal a fertiliser?

Ash accounts for a proportion of fresh biochar containing nutrients and minerals that can boost plant growth - the main reason for slash-and-burn farming. However, soils treated in that manner are depleted after one or two harvests. Biochar proponents recognise that nutrients and minerals are quickly depleted, but maintain that biochar can improve yields nonetheless by enhancing the uptake of nutrients from other fertilizers, improving water retention and encouraging beneficial fungi. This has been proven for Terra Preta, however the evidence for modern biochar is, yet again, inconclusive. In some cases, biochar can inhibit rather than aid beneficial fungi.[90] Furthermore, the lack of long-term field studies means that there is little evidence extending beyond the initial period when charcoal still retains nutrients and minerals. Even during this initial period, it has been shown that charcoal can in some cases reduce plant growth, depending on the type of biochar and the crops on which it is used.

Where biochar does increase yields - at least in the short-term - it appears to do so mainly by working in conjunction with nitrogen fertilisers.[91] Hence, companies such as Eprida are looking to produce not just charcoal but a combination of charcoal with nitrogen and other compounds scrubbed from flue gases of coal power plants. Such a technology bears little resemblance with Terra Preta and instead perpetuates fossil fuel burning and the use of fossil-fuel based fertilisers in industrial agriculture.

Black carbon, tilling and global warming

Although black carbon is being discussed as a carbon sink while it remains in the soil, airborne black carbon is a major cause of global warming. Proportionally, black carbon has a global warming impact which is 500-800 times greater than that of CO_2 over a century.[92] Although it is not a greenhouse gas, black carbon reduces albedo, i.e. it makes the earth less reflective of solar energy. The small, dark particles absorb heat and contribute to ice melting in the Arctic and elsewhere.

Biochar advocates argue that charcoal can help to reduce black carbon emissions if open cooking fires are replaced by charcoal-making stoves. However, any type of 'clean' biomass stove will reduce atmospheric black carbon emissions - not just charcoal making ones. Some also argue that biochar can reduce black carbon emissions from slash-and-burn fires by making soils permanently fertile. Bus as discussed above, such fertility improvements are far from proven.

On the other hand, a serious concern is that some of the more finely powdered charcoal will become airborne during application and handling. On the one hand tilling biochar deep into soils would minimise biochar losses. On the other hand, tilling can damage soil structures and causes breakdown

86 Wardle D.A., Nilson M.Ch. & Zackrisson O. (2008): Fire-Derived Charcoal Causes Loss of Forest Humus. Science 320(5876): 629; also see comment by J. Lehmann & S. Sohi, 10.1126/science.1160005 and authors' response. 10.1126/science.1160750; http://www.sciencemag.org/cgi/content/abstract/320/5876/629

87 Rogovska *et al.* (2008): *Greenhouse gas emissions from soils as affected by addition of biochar.* presentation see footnote 6.

88 Wilson Bruun et al. (2008): Biochar in fertile clay soil: impact on carbon mineralization, microbial biomass and GHG emissions. poster at SASS conference; http://www.biochar-international.org/ibi2008conference/ibiposterpresentations.html

89 Reijnders L. (in press): *Are forestation, bio-char and landfilled biomass adequate offsets for the climate effects of burning fossil fuels?* Energy Policy: doi:10.1016/j.enpol.2009.03.047

90 See for example Warnock *et al.* (2008): *Non-herbaceous biochars (BC) exert neutral or negative influence on arbuscular mycorrhizal fungal (AMF) abundance.* presentation, see footnote 81.

91 See for example Chan K.Y.,Van Zwieten L., Meszaros I., DownieA. & Joseph S. (2007): *Agronomic values of greenwaste biochar as a soil amendment.* Australian Journal of Soil Research 45: 629-634.

92 See: Bond T.C. & Sun H. (2005): *Can Reducing Black Carbon Emissions Counteract Global Warming?* Environmental Science & Technology 39: 5921-5926;and James H., Sato M., Kharecha P., Russel G., Lea D.W. & Siddal M. (2007): *Climate Change and Trace Gases.* Philosophical Transactions of the Royal Society 365(1856):1925-1954.

of pre-existing soil carbon. Laying biochar near the soil surface will result in more exposure to erosion and oxidation and could ultimately become a major contributor to airborne black carbon. These problems are well illustrated in pictures from a study commissioned by the biochar company Dynamotive[93] which show large clouds of charcoal dust during transport and application. The researchers report that 30% of the charcoal was lost in this manner. The significance of airborne particles also illustrated by the fact that dust carried from the Sahara is routinely deposited in the Amazon Basin. Even if a small percentage of the biochar hat is lost becomes airborne, it would result in biochar worsening global warming irrespective of any carbon sequestration.

Large scale biochar?

Regardless of the small-scale impacts, creating a large new demand for biomass can be expected to compete with existing and already unsustainable demands and to further increase pressure on natural ecosystems, on community lands and on food production. Biochar advocates claim that they do not advocate deforestation for biochar plantations. However, the large quantities of biochar promoted - with 1 billion tonnes of carbon sequestration per year quoted as a 'lower range' - make further pressure on ecosystems and land inevitable. Johannes Lehmann (IBI) for example states that the greatest potential would come from dedicated crops and trees,[94] and a discussion at the 2008 IBI Conference suggested that plantations would be required for scaling up biochar.[95] Advocates and companies promoting agrofuels also claim that they do not advocate for practices that drive deforestation or degradation of ecosystems. Such impacts are well known to occur directly as well as indirectly. Meanwhile, demand for agrofuels is moving the agricultural frontier further into tropical forests, destroying remaining biodiversity, leading to the displacement and eviction of growing numbers of indigenous peoples, small farming communities and displacing food production.

This was- and still is - the major concern behind a declaration “Biochar: A new big threat to people, land and ecosystems” signed by over 150 organisations in spring 2009.[96]

5. Genetic engineering, agriculture, biomass production and climate change

Biotechnology and agrochemical companies promote similar messages: population is predicted to rise by 50% to some 9 billion by 2050, so we must increase food production by 50-100% in order to meet new aspirations for meat consumption. In addition, we face climate change and peak oil so we need to produce an increasing proportion of energy and fuels, including first and second generation agrofuels, from biomass. However, there are insufficient natural resources including land and water for this expansion, so we must produce more from each hectare. For this we need crops with increased yields. At the same time, we must also respond to climate change so we need plants that can flourish in conditions of greater extremes of weather, heat, flood and drought. Because much land is saline, due to irrigation and flooding, we also need salt tolerant crops. Since synthetic nitrogen fertilizer in particular is energy intensive to produce and since not all of it is taken up by the crop plants resulting in N_2O greenhouse gas emissions and nitrate leaching, biotech research also needs to develop crop plants capable of fixing their own nitrogen.

Finally, a considerable amount of energy is required to break down biomass from trees and other plants into the sugars required for agrofuels and other industrial products. So biotechnology proponents promise GM plants that will break down more easily, and enzymes and microorganisms that will reduce the need for energy, and therefore emissions, in industrial processes.

In sum, the biotech companies promise to feed the expanding human population, to replace fossil fuels and to tackle climate change through genetic

93 See footnote 15.

94 Lehmann J., Gaunt J. & Rondon M. (2006): *Biochar sequestration in terrestrial ecosystems.* Mitigation and Adaptation Strategies for Global Change 11: 403–427.

95 IBI (2008): IBI Conference 2008; Session D: Biochar and bioenergy from purpose-grown crops and waste feedstocks/waste management. http://www.biochar-international.org/images/IBI_2008_Conference_Parallel_Discussion_Session_D.pdf

96 Declaration: ‘Biochar’, a new big threat to people, land, and ecosystems. 26.3.2009;http://www.regenwald.org/international/englisch/news.php?id=1226

engineering.[97] And if that should fail, they promise synthetic biology to custom-build microorganisms.

Increased yield: The biotech industry regularly claims that the currently available genetically modified (GM) crops already show increased yield, even though their GM traits are herbicide tolerance and insecticide (Bt) production in soya, maize (corn) and cotton. However, careful examination shows that this is not the case. For some GM crops, such as herbicide tolerant soya,[98] even *lower* yields compared to conventional varieties could be observed.[99] It is also important to distinguish between actual (*intrinsic*) yield increase that is caused by the growth performance of the plant and *operational* yield increase, caused by a reduction of losses from pests and diseases or improved farming practises. The Union of Concerned Scientists notes in its recent report *Failure to Yield*[100] that "no currently available transgenic varieties enhance the intrinsic yield of any crops" and attributes rises in intrinsic yield to conventional breeding.

The claim that herbicide tolerant GM crops in non-till agriculture are already a method to fight climate change is discussed in chapter 3.

5.1 Claims for future biotech crops and trees

New crops for yield increase: Over the last 10 to 15 years, many attempts and trials have been undertaken to develop GM crops for higher intrinsic yield. No such crop has so far been proposed for commercial use, and little scientific information is available on how such yield increases could be achieve.[101]

97 For example: Monsanto (2009): Sustainable Agriculture. website, accessed 17.5.2009,http://www.monsanto.com/responsibility/sustainable-ag/default.asp; Syngenta (2009): Syngenta calls for greater international collaboration to address food security challenge. press release 21.4.2009,http://www.syngenta.com/en/media/mediareleases/en_090421.html; DuPont (2009): Welcome to DuPont biotechnology. website, accessed 17.5.2009, http://www2.dupont.com/Biotechnology/en_US/; Bayer (2009): Bayer CropScience calls for a "Second Green Revolution", press release, 17.4.2009; http://www.bayercropscience.com/BCSWeb/CropProtection.nsf/id/EN_20090417_1?open&l=EN&ccm=500020

98 RoundupReady (RR) soya, tolerant against glyphosate

99 Steinbrecher R.A. & Lorch A. (2008): *Feed the World?* The Ecologist, Nov. 2008: 18-20.

100 Gurian-Sherman D. (2009): Failure to Yield: Evaluating the Performance of Genetically Engineered Crops. Union of Concerned Scientists;http://www.ucsusa.org/food_and_agriculture/science_and_impacts/science/failure-to-yield.html

101 Steinbrecher& Lorch 2008

Abiotic stress tolerance: For many years the biotech industry has promised salt, heat, flood and drought tolerant crops to deal with soil and water degradation due to land-use change, over-exploitation and industrial monocultures. Climate change has intensified the need for abiotic stress tolerance in crops, but this does not mean we must develop stress tolerant GM crops. Abiotic stress tolerance can also be developed through conventional breeding or by using already adapted crop varieties.

The currently grown first generations of herbicide tolerant and insecticide expressing (Bt) crops are simply modified to produce an additional protein, and even that cannot be done precisely, producing unexpected effects. Projected new GM traits like stress tolerance involves complex interactions among many genes and molecular signal pathways. Indeed,the simple equivalence between a gene and a trait is the exception rather than the rule, and the interactions between (groups of) genes, proteins and chemical compounds involved in conferring abiotic stress tolerance are neither fully understood nor predictable. Even when single genes are identified that are correlated with stress tolerances, this is still a long way from actually being able to develop and test a GM plant.

According to Osama El-Tayeb, Professor Emeritus of Industrial Biotechnology at Cairo University:

> "[…] transgenicity for drought tolerance and other environmental stresses (or, for that matter, biological nitrogen fixation) are too complex to be attainable in the foreseeable future, taking into consideration our extremely limited knowledge of biological systems and how genetic/metabolic functions operate."[102]

Other promised GM solutions include:

- **nitrogen-fixing for non-leguminous plants** to reduce dependence on chemical nitrogen fertilizers. As El-Tayeb pointed out above, this trait too depends on complex interaction of several genes, and any attempts have failed so far.
- **enhanced uptake and utilization of nitrogen** to enable plants to make full use of all the nitrogen present in the soil, no matter whether these are nutrient poor or strongly

102 El-Tayeb O. (2007): Alternatives to genetic modification in solving water scarcity; email comment28.3.2007Electronic Forum on Biotechnology in Food and Agriculture; http://www.fao.org/biotech/logs/C14/280307.htm

fertilized soils. Attempts to genetically modify rice and other crops for high nutrient use are still in early stages, as currently there is poor understanding of how the genes involved are regulated.

- **altered temperature/geographic range** to enable plants to grow outside their usual climatic conditions and regions; for example cold-tolerant eucalyptus trees.[103] The dangers of such an approach have not been assessed yet, but since eucalyptus is an invasive species, the risk exist that it becomes even more invasive and disrupts ecosystems by displacing native species. GM trees and other plants growing in a new environment will also start interacting unpredictably with other organisms, including pests.
- **converting C3 plants into C4 plants:** Summarized very briefly, C4 plants such as maize, sugarcane and millet are considered to photosynthesise, tolerate heat and use water more efficiently than C3 plants (e.g. potato, rice, wheat and barley), and therefore might be adapted better to climate change conditions. Yet conversion from C3 to C4 would involve modifying the complex photosynthetic system of the plant.
- **resistance to emerging pests and diseases:** Current GM crops have led to the emergence of herbicide tolerant weeds, new pest and disease patterns. In response, the biotech industry is developing crops stacked with different patented genes for herbicide tolerance and insect resistance. With SmartStax™, a GM maize with as much as eight GM traits is under development.[104] Also promised is a cotton that tolerates two herbicides, dicamba and glufosinate. However, It is likely that even stacked crops will generate pest resistance, thus continuing the race between technology developers and pests that is familiar from the green revolution and earlier generations of genetically engineered crops.[105] And even in stacked GM crops, insecticide production never works against all pests, but leaves the plant just as vulnerable to other (secondary) pests. Climate change will bring to bear its own unpredictable shifts, complexities and pressures.

Patents, confidentiality and funding for climate-ready crops: A major problem with research into the new GM crop developments is that "besides general statements and website announcements, there is no information available about the scientific basis of this work."[106] Indeed *Confidential Business Information* (CBI) claims applied to GM techniques as well as to genes and DNA sequences severely reduces public access to information about novel crops and their claimed impact on climate issues. Pending patent applications have the same effect, while granted patents and other intellectual property devices limit access by scientific researchers to both information and genetic material. ETC group describes how the five major biotech corporations between them have filed more than 500 patents "on so-called 'climate-ready' genes at patent offices around the world."[107] In addition, agricultural research and development is increasingly carried out by the private sector, which obviously has a vested interest in monopolizing rather than sharing any inventions or discoveries they may make. All this makes it more difficult and costly to access information and material for research. Absence of information about new developments makes it hard to assess them. In a world faced with climate change, information needs to be freely and fairly shared.

So, while there are numerous ideas for future GM crops to address climate change, none of them seem to be feasible at the moment. Were they to be developed, the thorough risk assessments required before the introduction of fundamentally changed GM crops, means that any practical

103 developed by the company Arborgen and released in field trials in the US

104 Dow AgroScience (2007): Monsanto, Dow Agreement Paves the Way for Industry's First-Ever, Eight-Gene Stacked Offering in Corn. press release 14.9.2007. http://www.dowagro.com/newsroom/corporatenews/2007/20070914a.htm
"Under the agreement, the companies will create a novel seed offering that combines eight different herbicide tolerance and insect-protection genes into top-performing hybrids for the most complete control ever available. The product will include the companies' respective above- and below-ground insect protection systems, including Dow AgroSciences' Herculex® I and Herculex RW technologies; Monsanto's YieldGard VT Rootworm/RR2™ and YieldGard VT PRO™ technologies; and the two established weed control systems, Roundup Ready® and Liberty Link®."

105 Paul H. & Steinbrecher R.A. (2003) *Hungry Corporations: Transnational Biotech Companies Colonise the Food Chain.* Zed Books, UK: p. 9.

106 Steinbrecher R.A. & Lorch A. (2008): *Feed the World?* The Ecologist, Nov. 2008: 18-20.

107 etc group (2008): *Patenting the "Climate Genes"... And Capturing the Climate Agenda*. Communiqué May/June 2008. http://www.etcgroup.org/en/materials/publications.html?pub_id=687

application is a long way off. Concentrating on such GM crops therefore carries high opportunity costs, losing time and money that could be invested in other, more promising, less risky approaches.

Such GM crops, if developed, would also be likely to be associated with the model of industrialized, monoculture agriculture, which is where they have been most successful to date.

5.2 Bioeconomy, genetic engineering and biomass

Genetic engineering is also experimentally applied to the conversion of biomass (including whole crop plants and residues) into agrofuels and other alternatives to fossil fuels. The aim is to use less energy in the process and reduce emissions of greenhouse gases. This is also the area for which synthetic biology is promoted. Experimental applications include:

- changing the ratio of lignin to cellulose in the biomass so that it can be more easily broken down and converted into products such as bioplastics. In general woody plant material is difficult to process due to its high lignin levels, and research is underway for example with poplars to reduce lignin levels in favour of cellulose levels. The risks of GM trees for global forest ecosystems is regarded as potentially very high, with serious implications for climate change;[108]
- GM algae to produce agrofuels, since existing algae do not offer consistent commercial yields;
- GM enzymes and/or microbes for insertion into crops or for use in processing plants to promote breakdown of biomass; and
- artificial (synthetic) microorganisms for multiple purposes.

Such ideas are key to the new *bioeconomy* that is of crucial interest to biotech companies. The OECD, EU and US are investing considerable intellectual and financial resources into various bioeconomy projects. EuropaBio, the European biotechnology industry association, succinctly describes the *biorefineries* as the central concept of the bioeconomy:

> "A biorefinery transforms biomass derived from renewable raw materials into a wide range of commodities by the means of advanced biotechnological processes such as enzymatic hydrolysis. The biomass comes from a variety of sources such as trees, energy crops such as switchgrass and agricultural products such as grain, maize and waste products such as municipal waste. Biorefineries can produce commodities such as bioethanol, bioplastics, biochemicals and ingredients for the food and feed industry."[109]

The biorefinery concept symbolises the manner in which the pursuit of the bioeconomy brings together the interests and experience of the major agricultural and chemical industries (e.g. seed, fertilizer, pesticide, commodities and biotechnology) with the energy sector, including the oil, power and automotive industries.

The development of the bioeconomy implies that huge areas of the planet will be turned over to massive monocultures of biomass raw material for processing in biorefineries. This prioritises the use of biomass for economic purposes over ecological purposes such as protecting biodiversity or ecosystems. Furthermore demand is potentially limitless as massive increases in energy consumption are predicted. This is compounded by the fact that plant biomass has low energy density in comparison with the fossil fuels it is meant to replace. The development of the bioeconomy would further extend all the well-documented impacts of industrial agriculture on soils, water, biodiversity, ecosystem integrity, small-scale farmers, local communities and indigenous peoples. It could signal the end of major tracts of forest and other vital ecosystems. The irony is that this would all take place in the name of tackling climate change.

Conclusions

Some of the risks of climate-ready crops, GMOs and GM enzymes for biorefineries can already be anticipated now, but many will be completely new and potentially greater. Already now, studies show that even comparatively simple forms of genetic engineering throw up completely unexpected effects.[110] Currently risk assessment relies on assumptions of equivalence and familiarity but

108 Steinbrecher R.A. & Lorch A. (2008): *Genetically engineered trees & risk assessment. An overview of risk assessment and risk management issues.* Vereinigung Deutscher Wissenschaftler, Berlin, Germany.

109 EuropaBio (2009): *Today's applications. Biorefinery.* website, accessed 17.5.2009. http://www.bio-economy.net/applications/applications_biorefinery.html and EuropaBio (2007): *Biofuels in Europe. EuropaBio position and specific recommendations.* June 2007. http://www.europabio.org/positions/Biofuels_EuropaBio%20position_Final.pdf

such basis will not be available for microorganisms, algae, crops and trees with fundamentally different traits, different cell regulation and/or different synthetic pathways.

Regardless of whether such complex GM crops can ever be developed, they are not ready now and may not be for many years. But we need action *now* to counter climate change and to stop the destruction of biodiverse ecosystems that help to regulate climate.

There are ways to address the problems, but they are in the public domain where information and experience is shared, not sold. Naturally enough, the large corporations and venture companies that increasingly dominate agricultural research seek returns for their shareholders, which is their obligation. Hence there is a vacuum in research and development in and applications of f forms of agriculture that can protect and rebuild resources for the future in the common interest.

6. 'Marginal land': Enclosure, appropriation and degradation of ecosystems

Much of the debate about climate change mitigation and adaptation is premised on gaining access to land. Land is claimed for agrofuel and food production by corporations and foreign governments, for speculation by funds seeking to attract investors into agriculture[111] – and also in the name of protecting biodiversity from all these pressures. In some cases governments are zoning national land for conservation or exploitation and possibly looking to trade one against the other. In the last few months there have been a number of news stories about the acquisition of land by oil-producing nations plus China, India, Korea, Vietnam and others for food production. At the same time, deals involving millions of hectares of land for the production of agrofuels are also under discussion. Potential deals include 2.8 million ha in the Democratic Republic of Congo for oil palm agrofuel and 2 million ha for jatropha agrofuel in Zambia, both for China.[112] When the talk turns to amounts of land required to produce biochar, ostensibly to address climate change, areas up to 2 billion hectares have been mentioned.[113,114]

So it is not surprising that we are constantly told that there are vast extents of marginal, degraded, under-used, abandoned, sleeping and waste land, that will not compete with food production and are just waiting to be brought into production for biofuels and biochar as co-products. Additionally, we are also told that this land can potentially be restored by planting so-called advanced crops for agrofuels or biochar, creating a win-win situation.[115]

Yet others are quick to say that much of this land is actually common: collective land used by local people.[116] Although frequently they have no formal title of ownership to the land - just customary right - it may be a vital resource for water, food in times of drought, medicine and materials, especially to the most marginalised people.[117] Jonathan Davies, global co-ordinator of the World Initiative for Sustainable Pastoralism, Nairobi, Kenya, comments:

> “These marginal lands do not exist on the scale people think. In Africa, most of the lands in question are actively managed by pastoralists, hunter-gatherers and sometimes dryland farmers […] There may be wastelands lying around to be put under the plough, but I doubt that they are very extensive.”[118,119]

110 Wilson A.K,, Latham J.R. & Steinbrecher R.A. (2006): *Transformation-induced Mutations in Transgenic Plants: Analysis and Biosafety Implications.* Biotechnology and Genetic Engineering Reviews, 23: 209-237

111 See for example the investment management firm Emergent and their *Emergent Africa Land Fund*; http://www.eaml.net/templates/Emergent/home.asp?PageId=7&LanguageId=0

112 von Braun J. & Meinzen-Dick R. (2009): *“Land Grabbing” by foreign investors in developing countries: Risks and opportunities.* IFPRI Policy Brief 13; http://www.ifpri.org/pubs/bp/bp013Table01.pdf; and http://www.ifpri.org/pubs/bp/bp013.pdf

113 Read D. (2006): *Treasury review of the economics of climate change. Submission from Dr Peter Read*. Stern review evidence, 12.3.2006; http://www.hm-treasury.gov.uk/d/massy_uni_2.pdf

114 Chung E. (2009): *Ancient fertilizer technique could help poor farmers, store carbon.* CBC News, 23.3.2009; http://www.cbc.ca/technology/story/2009/04/23/tech-090423-biochar-carbon-trading.html

115 Gallagher E. (2008): *The Gallagher Review of the indirect effects of biofuels production.* Renewable Fuels Agency; http://www.renewablefuelsagency.org/reportsandpublications/reviewoftheindirecteffectsofbiofuels.cfm

116 Mausam, July-September 2008; http://www.thecornerhouse.org.uk/pdf/document/Mausam_July-Sept2008.pdf

117 Nyari B. (2008): Biofuel land grabbing in Northern Ghana. http://www.biofuelwatch.org.uk/files/biofuels_ghana.pdf

118 The Gaia Foundation, Biofuelwatch, the African Biodiversity Network, Salva La Selva, Watch Indonesia & EcoNexus (2008): *Agrofuels and the Myth of the Marginal Lands.* Briefing paper; http://www.econexus.info/pdf/Agrofuels_&_Marginal-Land-Myth.pdf;

119 Donizeth D.J. (2008): India’s Policy on Jatropha-based Biofuels: Between Hopes and Disillusionment. Focus on the Global South, 22.9.2008;

'Marginal land' is not usually rich and fertile, but more often nutrient poor with harsh environmental conditions. Though many rely on it for their survival, it requires detailed knowledge and experience to do so.

What are the impacts of turning marginal land over to monocultures?

There are a wide variety of impacts on people, ecosystems and biodiversity, and the relationship between them. The people who inhabit such areas are often themselves marginal, largely invisible to policy-makers and international institutions. Among those likely to suffer most from expropriation of such lands are **women**, who often have no property rights or access to land. As a FAO report of 2008 states: "The conversion of these lands to plantations for agrofuels production might therefore cause the partial or total displacement of women's agricultural activities towards increasingly marginal lands."[120]

However there is ongoing pressure to convert their land to more 'productive' uses, such as crop cultivation, without paying attention to the potential climate impacts of so doing. One study "provides evidence of the complex connection between regional changes in climate and changes in land cover and land use. New study results are warning that the conversion of huge areas of pasture lands to croplands in east Africa will be a major contributor to global warming in the region."[121]

An other group that would suffer are **pastoralists**. Both they and their way of life are widely misunderstood, increasingly marginalised and hemmed in by settlements, borders and parks, yet they should actually be vital to discussions about adaptation to climate change:

> "Mobile pastoralists are amongst those most at risk to climate change, yet they are amongst those with the greatest potential to adapt to climate change, and they may also offer one of the greatest hopes for mitigating climate change."[122]

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Like pastoralists, **indigenous peoples** and **small-scale farmers** are extremely vulnerable to climate change with its associated extremes of droughts, floods and storms, as well as shifts in local climate and vegetation. Like pastoralists, they are also in danger of being expropriated, with the additional excuse that this would be done to protect the climate. However, policy-makers are inclined to forget that the relationship between people and marginal land may be subtle and complex and the insights of the people may be crucial for protecting biodiversity and the integrity of ecosystems, which are vital buffers against the impacts of climate change.

Land rights and agrarian reform

The recognition of their land rights is a fundamental need for marginalised peoples and small-hold farmers. However, Olivier De Schutter, the Special Rapporteur on the Right to Food, noted in his report to the UN General Assembly that "no governmental delegation present at the High-Level Conference on World Food Security [held in June 2008 as the food crisis increased] mentioned agrarian reform or the need to protect the security of land tenure."[124]

Marginal land as important reserve and biodiversity adaptation centre

Marginal land with poor soils can be home to a highly biodiverse population of plants and animals in dynamic interaction. Although little studied, such marginal areas may prove to be extremely

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http://focusweb.org/india/index.php?option=com_content&task=view&id=1069&Itemid=26
Navdanya (2007): *Biofuel hoax: Jatropha and land grab.* Press release, 5.12.2007; http://www.navdanya.org/news/5dec07.htm

120 Rossi A. & Lambrou Y. (2008): *Gender and equity issues in liquid agrofuels production - Minimising the risks to maximise the opportunities.* FAO; www.fao.org/docrep/010/ai503e/ai503e00.HTM

121 Maitima J.M. (2008): *Climate Land Interaction Project.* International Livestock Research Institute (ILRI); http://www.ilri.org/ILRIPubAware/ShowDetail.asp?CategoryID=TS&ProductReferenceNo=TS_080722_001

122 Davies J. & Nori M. (2008): *Managing and mitigating climate change through pastoralism*. Policy Matters 16: 127-141. http://cmsdata.iucn.org/downloads/pm16_section_3.pdf

123 Maitima J.M. (2008): *Climate Land Interaction Project.* International Livestock Research Institute (ILRI); http://www.ilri.org/ILRIPubAware/ShowDetail.asp?CategoryID=TS&ProductReferenceNo=TS_080722_001

124 De Schutter O. (2008): *Report of the Special Rapporteur on the right to food, Olivier De Schutter: Building resilience: a human rights framework for world food and nutrition security.* UNHCR, A/HRC/9/23, 8 September 2008.

important. The plants must continuously adapt to harsh, often rapidly changing conditions, so such land could be a vital source of genetic diversity for resistance to stresses such as drought, disease and pests in the future, especially as climate change threatens the viability even of locally adapted farmer varieties of crops.[125]

In Europe and the US, land designated as set-aside or belonging to the Conservation Reserve Program (CRP) may also be a crucial refuge for biodiversity. However, it is often considered marginal and may readily be sacrificed to boost production of food crops or agrofuels. This has already be occured both in the EU[126] and the US, prompting immediate fears over the fate of wildlife. In the US, there are proposals from researchers to turn vast regions of marginal, unused and fallow land over to GM poplar trees with altered or reduced lignin for the production of second generation fuels[127] - supposedly to address climate change. Such contradictions are embedded in the proposition that biomass production should be scaled up, particularly on so-called marginal lands, and need to be urgently addressed.

Conclusions

Land that is classified as marginal often has great value to people, biodiversity and ecosystems and for climate stabilisation. Turning it over to industrial cropping for food or fuel may increase regional and global climate change. We need to put the knowledge of small-scale farmers, pastoralists and indigenous people at the centre of the debate about marginal land and how to restore the integrity of ecosystems, especially in dry regions. Turning it over to biomass production or biochar experiments is ill advised.

7. The livestock industry at a turning point

Livestock emissions account for 9% of CO_2 equivalent derived from all human related activities and generates 65% of human-related nitrous oxide, most of it from manure; 37 percent of human induced methane, and 64% of ammonia. These data include feed but exclude the high carbon emissions from land use and its changes that are particularly uncertain to quantify. For the agriculture sector, livestock constitute nearly 80% of all emissions. With 18% of total emissions, livestock is calculated to have a higher share than transport.[128] These emissions make livestock a major target for mitigation options. Reducing methane emissions from factory farms in biogas digesters is currently a major CDM project activity, raising a false hope that intensification in the livestock sector could save the climate.

The livestock revolution, a climate killer

Within a few years, the "livestock revolution" has changed agriculture in most developing countries. Asia has overtaken Europe in terms of milk production, and in 2004, Brazil overtook the USA as the world's main meat exporter. Massive subsidies and favourable regulations have supported the growth of industrial livestock production. The problems that came along with factory farms like water, soil and air pollution, and severe compromises of animal health and welfare have largely remained unsolved. Locally available feed like grass and other roughage, as well as nutrient-rich waste from farms and households were replaced by compound feed manufactured in feed mills from resources that compete with food, produced and transported over long distances with a negative climate impact.

The animal breeding lines selected for high output, need standardized feed, intensive veterinary treatment and a controlled environment, e.g. 'biosecure' enclosures to prevent infections. Resistance to diseases and pests, vitality, fertility and mothering abilities were largely opted out by selective breeding.

Scientists agree that high densities of animals with low immune systems are a recipe for diseases, but traditional breeds are eliminated because they often carry diseases, without themselves becoming sick. The genetic diversity in most industrial cattle and pig breeding lines is dangerously low.

There is no independent information available for the poultry sector because the diversity is a trade secret of the four breeding companies that supply the world with poultry genetics.

Globally, three quarters of broiler chicken, two thirds of milk, half of the eggs and a third of the pigs come from industrial breeding lines. These numbers are planned to further increase:

125 Melaku Worede, Ethiopian geneticist, one of the founders of Seeds of Survival and a specialist in uncultivated biodiversity, pers communication.

126 Smith J. (2007): EU moves to scrap set-aside to boost grain supply. Reuters, 16.7.2009; http://uk.reuters.com/article/latestCrisis/idUKL1633601820070716

127 Purdue University (2006): *Fast-growing trees could take root as future energy source.* http://www.monsanto.co.uk/news/ukshowlib.phtml?uid=10618

128 Steinfeld H., Gerber P., Wassenaar T., Castel V., Rosales M. & de Haan C. (2006): *Lifestock's long shadow. Environmental issues and options*. FAO, Rome.

- "Dairy Pakistan" is a plan to replace the buffaloes grazing on natural vegetation with grain fed cattle. Pakistan is the world's fourth largest milk producers.[129] (see text box)
- China, where half of the world's pigs are kept, will replace its smallholder pig production with compound fed factory animals within the next few years.

Industrialized milk production in Pakistan: Pakistan is the fourth largest milk producer in the world, with the lowest production cost; milk consumption currently is a litre per person per day. Nestlé is the most powerful consumer goods company in Pakistan. In order to increase its access to milk, Nestlé is planning to replace the buffaloes with industrial dairy cattle breeds, and Dutch as well as Australian public funds are supporting the replacement. Buffaloes thrive well on local feed, and their milk is highly valued by smallholders and consumers. But industrial breeds, if fed with concentrate feed, produce a larger and steadier amount. The world's largest milk-processing factory is being set up in Kabirwala, Pakistan, by Nestlé.

The local NGO Punjab Lok Sujag has stated that pasteurisation and packaging does not help consumers or farmers, who are both well supplied with healthy milk products, but corporations, which increase the price they charge consumers and decrease the price paid to farmers. Corporations like Nestlé have been living on heavily subsidised Western dairy farming systems. They are now substituting it with cheap supplies from small production units run by very poor Pakistani families.[130]

Aquaculture will add to the problem. In the North, 70% of aquaculture requires fishmeal, fish oil and grains. In Asia, where 80% of aquaculture production takes place, compound feed use is increasing. Depletion of small pelagic fish for fishmeal and fish oil has fundamentally disturbed the oceans' food web. Especially carnivore species like salmon, trout and shrimp are problematic but herbivores also are now often fed with compound feed for faster growth.

A third of the cultivated land currently serves to produce feed grain. More than 90% of global soybean production is for feed.[131] The carbon emissions from feed grain production include:

- 41 million tonnes from fossil fuel use to produce the fertilizer;
- 90 million tonnes from on farm fossil fuel use; and
- 10-50 million tonnes from processing, mainly related to factory farms.

Far greater emissions have also to be added that are caused by the destruction of forests and other ecosystems.

Manure, a valued fertilizer

Animal manure is an important fertilizer in crop production and highly valued. Especially in view of the long term limitation and rising cost of petrochemicals, trade in manure is increasing. From the emission perspective, manure is an emitter of high amounts of greenhouse gases.

Indeed, factory farms and feedlots that manage manure in liquid form, are releasing 18 million tonnes of methane annually. Manure deposited on fields and pastures does not produce significant amounts of methane.[132] Thus, biogas reactors are trying to mitigate emissions from industrial livestock production that do not exist in other livestock production systems. These particularly aggressive emissions amount to just three percent of anthropogenic methane emissions, but three percent could be crucial in mitigating climate change.

Nitrogen availability is a key factor for life and plays a central role in the functioning of ecosystems and the cycling of carbon and soil minerals. The sources of nitrogen available to crop production include nitrogen fixing bacteria that live in association with the roots of leguminous plants. Another important source are living and dead organisms, and this includes manure. Petrochemical fertilizer is currently providing around 40 percent of nitrogen to the agricultural crops. Half of the synthetic fertilizer nitrogen can't be used by plants, and excessive nitrogen fertilization is polluting ecosystems. Animals in

129 Pakistan Dairy Development Company (2006); *White paper on Pakistan's dairy sector.* http://www.pddc.com.pk/DairyPakistan-Publication.pdf

130 Gura S. (2008): *Industrial livestock production and its impact on smallholders in developing countries.* Consultancy report to the League for Pastoral Peoples and Endogenous Livestock Development, Germany. http://www.pastoralpeoples.org

131 Steinfeld *et al.* 2006.

132 Steinfeld *et al.* 2006

general are inefficient nitrogen users, and particularly the nitrogen excretion of ruminants is high. But when they are fed roughage like grass or bran, and their excreta returned to soils, their nitrogen inefficiency has no negative impact on the environment.[133]

Nitrogen emissions of factory farms, together with emissions of phosphate, potassium, drug residues, heavy metals and pathogens, are a major problem associated to industrial agriculture. The Netherlands, where the population density is high and agriculture intensive, have limited the number of pigs fattened in the country, to control pollution of water, soil and air.

Feed conversion ratio or life cycle assessment?

The reduction of the feed conversion ratio, i.e. the amount of feed required to produce meat, eggs or milk, is the major objective of livestock and aquaculture breeding. Faster growth and better use of feed have been achieved over the past decades. Proponents of the livestock revolution claim that a further intensification would thus save the climate,. But by further increasing total production, by externalising environmental costs of feed production, and by ignoring massive animal health and welfare problems, climate change is not mitigated but exacerbated.

The underlying notion of productivity needs revision. It cannot any longer be the decisive argument how many eggs a hen lays per year. The greenhouse gas emissions per product unit must relate to the climate impact of the whole product life cycle including the feed footprint. In addition, other environmental and social costs as well as macroeconomic effects need to be included, since agriculture fulfills these vital functions. Ignored by agribusiness accounting, these aspects of productivity are usually also omitted from macro-economics and thus not within the perspective of policy makers.

Industrial aquaculture not a climate saver

Aquaculture is promoted as an efficient feed user. The feed industry claims that it only takes 2 kg of feed to produce 1 kg of live fish, while poultry requires 3 times and cattle 8-10 times the live weight. Or, as the WorldFish international research center puts it, 100 kilograms of feed will produce as much as 75 kilograms of catfish meat but only 50 kg of chicken meat or 13 kg of beef.[134] Aquaculture has grown in Asia, mainly China, with a rate of 10% over the past 50 years. Annual consumption of fish, shellfish and crustaceans per person in China has grown from 5 to 25 kg, whilst the world average has remained at 13-14 kg with little change. 70% of the Chinese fish production stems from aquaculture.

In polyculture systems several species occupy different trophic levels. Such ponds are integrated into the farming system, notably with pig, poultry and vegetable production, and with mulberry trees to raise silk worms. Similar integrated systems are found in many parts of South and South East Asia. As well as producing food, such polyculture systems provide important ecosystem services, including the recycling and use of various nutrients from solid waste and waste water. Pests and diseases are reduced, as the fish eat a number of parasite hosts like mosquito larvae and snails. Asian rice fields were known for their rich aquatic biodiversity and their contribution to pest control, until the chemicals brought in by the Green Revolution reduced these ecosystem services.[135] The World Bank suggested that ecosystem services of Asian aquaculture systems could be as valuable as food production. The two roles could complement each other if waste nutrients are transformed into feed. A precondition is however, that wastes from industry and from domestic use, are collected separately.[136]

However it is not integrated polyculture systems that are now propagated, but industrial aquaculture. With its compound feed requirements, industrial aquaculture will become a new burden to the climate. Already now, fish feed factories have been established in several Asian countries, and the feed is used in production for local markets as well as for export.

An increasing number of fish species are bred for higher output, sometimes describing industrial breeding as 'domestication'. As in livestock, breeding for industrial production has already created severe problems. In salmon, for example it has led to, among others,

- a breakdown of the newly established industry in Chile due to a pest and a virus disease. The production system was over-intensified.

133 Steinfeld et al. 2006

134 WorldFish Center (2008): F*ish, Food and Energy: balancing our approaches to meeting growing demand* http://www.worldfishcenter.org/wfcms/HQ/article.aspx?ID=132 (accessed 20.5.2009)

135 Halweil B. (2008): *Farming fish for the future.* Worldwatch Report 176.

136 The World Bank (2006): *Changing the Face of the Waters. Meeting the Promise and Challenge of Sustainable Aquaculture.* Washington.

- contamination of wild salmon populations with industrial breeding lines that outpace their wild competitors in growth and mating, but that are unfit to survive for long in the wild. Millions of industrial salmon have so far escaped, and pests and diseases that have become more virulent in cages, have now contaminated the wild populations.

In shrimps, recurrent disease outbreaks have caused severe problems to smallholders. For example, 80% of shrimp farmers in Thailand are now indebted. Moreover, their communities' natural resources, the mangroves, have been destroyed. The growing number of Vietnamese Pangasius export farmers are operating precariously close to break even. They export a million tons annually to Europe, a region oversupplied with animal food, but with a demand for fish double its own production. In Europe, industrial aquaculture is stagnating, limited for good reasons by restrictions like environmental and veterinary. The European Commission's new aquaculture strategy is to deregulate, subsidize and sell the unsustainable industrial GM feed and veterinary technology to Asia. Ecosystem services or life cycle assessments are not part of the strategy.

Turning a major CO_2 sink into food – and conserving it

Grassland covers 70% of the global agricultural land. The roots of pampas, prairies and tundra are a major CO_2 sink. The seasonal use by wild and domesticated herds contributes to grassland conservation as well as to its carbon sink function.

Only ruminants like cattle, goat, sheep, buffalo and camel can turn grass into food, and both, grassland and ruminants are resulting from co-evolution. Major environmental organisations including IUCN[137] are challenging myths around overgrazing and call for better regulatory support to mobile grazing management like pastoralism and transhumance. Seasonal grazing clearly contributes to biodiversity conservation. Thus, not only biodiversity is conserved, but also a major CO_2 sink maintained, *and* turned into highly valuable food. It is not the grazing, but changed use of grassland that contributes to climate change.

Extensive livestock raising is part of the cultures and livelihoods of millions. 70% of the world's poor keep livestock, including 190 million pastoralists. To them, livestock is not only a source of food and income, but also a source of textiles, fertilizer, draught power, status, cultural identity and credit - a bank on hooves. Even in industrialized countries, grassland plays an important role in agriculture, nutrition and society.

Two mitigation imperatives for the North: Eat less animal food, and eat organic

We are not arguing to replace the grain fed livestock by roughage fed livestock in the same numbers. Already, 70% of the Amazon has been replaced by grazing land;[138] cropland has taken one sixth of that amount. In 2007, Brazil overtook the US as the world's largest meat exporter. These internationally traded meat products, with the world's lowest production cost, are a major driver of deforestation.

The most effective mitigation approach is to reduce animal protein consumption. Eating more than 30-50g of animal protein per day is a waste of resources. The leading medical journal Lancet[139] has recommended a maximum of 90g. However, the global average of meat consumption, excluding dairy products, is around 100g, in industrialized countries it is far greater than 200 g per person per day. A higher developed economy does not automatically lead to higher animal protein consumption. Milk is not an essential food item, nevertheless a school milk programme was suggested in China by Nestlé[140] in order to get children used to dairy products and not lose their body's lactase enzyme production.[141] As a result, milk consumption grew by more than 15%t annually until the melamine scandal in 2008 interrupted the boom.

Obesity is an issue that must be addressed for many reasons including climate change. According to WHO data there are one billion obese persons - a number as big as the number of undernourished. The United Nations are the appropriate forum to take up the challenge on their collaborative

137 IUCN/World Initiative for Sustainable Pastoralism (WISP) (2008): Misconceptions surrounding pastoralism. accessed 20.5.2009; http://www.iucn.org/wisp/whatwisp/why_a_global_initiative_on_pastoralism_/?2313/Misconceptions-surrounding-pastoralism

138 Steinfeld *et al.* 2006

139 McMichael A.J., Powles J.W. Butler C.D. & Uauy R. (2007): *Food, livestock production, energy, climate change, and health.* The Lancet 370(9594): 1253-1263. http://www.eurekalert.org/images/release_graphics/pdf/EH5.pdf

140 Rohrer F. (2007): *China drinks its milk.* BBC News Magazine, 7 August 2007 .

141 Without the enzyme lactase, milk sugar consumption causes discomfort. The body stops producing lactase after when milk consumption is discontinued.

agenda. An increasing number of citizens and countries may be ready to break the taboo of unlimited animal protein supplies.

No such thing as cheap meat

Many consumers have started to realise, by now that they pay only part of the costs of cheap meat at the supermarket checkout, and that they also pay for subsidies and grants with their taxes: for livestock gene technology research, for preventing the spread of diseases, for dumping Northern products in the South, for conserving genetic resources in gene banks. Health and environmental damages take their toll as well. Consumer and animal welfare organisations all over the world concerned with the issue of industrial livestock production have been arguing that there is no such thing as cheap meat.

A German study showed that:

- conventional pork production is subsidised in Germany with billions of euros per year;
- external costs are 0.34 to 0.47 €/kg higher in conventional than in organic pork; and that
- the consumer price difference between organic and conventional pork stems largely from distribution and processing costs – economies of scale that would reverse if preferences shift to organic meat.[142]

Steps to get there

Livestock keeping can contribute to lower CO_2 emissions if roughage and nutrient rich waste from farms and households are used for feed and if less feed grain is grown on high fossil oil input. Long life spans and genetics adapted to the environment - not environment adapted to genetics - will increase efficiency. Although local breeds also contribute to the livelihoods of 70% of the world's poor, policies are putting them under pressure. On the fringes of the EU (Mediterranean, Baltic, Ireland) extensive livestock keeping has a renaissance due to demand for local products and recreation in a healthy environment. Such developments need attention, mainly by creating a level playing field and deleting the current support to the unsustainable livestock industry:

Save on subsidies and tax breaks: Between 800 million and 1.8 billion Euro per year of EU export subsidies were dished out over four decades to the EU dairy industry, putting smallholders in developing countries under pressure. They have been phased out, but meat export subsidies are still on as well as subsidies on grain production. Not only the Common Agriculture, but also the Common Fishery Policy has substantial subsidies. North America and developing countries as well provide substantial subsidies and tax breaks on which they could save. In Vietnam, for example, fifteen different kinds of subsidies and tax breaks are available to the pig industry, amounting for 19-70% of the gross margin.[143] China keeps increasing its subsidies to the livestock industry every year. The livestock industry faces substantial losses because of disease; for example 10-15% of the potential profit in poultry production. Increasingly, the industry demands that the taxpayers should bear the cost of disease control, adding to the high subsidies that maintain a highly uneconomical and unsustainable production system.

Change the focus of public research, which currently favours biotechnology. In spite of the public rejection, public research funds are allocated to genetically modified (GM) feed, GM animals, cloning and other technologies to intensify already over-intensified systems. Such public funding even includes budget lines for private patenting, and public awareness activities to change the public rejection of such products.

Stop deregulation: Globalisation has provided reasons to lift environmental and other regulations that protect people, animals and the environment. Improvements are extremely slow to achieve, in spite of high consumer awareness. The industry lobby is reaching far into some national administrations; and several corporations have accumulated market power and turnovers that override many national budgets. Their lobbying is strong enough to delay progress in UN negotiations, for example during the Fourth Meeting of Parties of the Biosafety Protocol in the Convention of Biological Diversity.

Establish national emission limits and limits to animal production The Netherlands, where the environment was severely affected by poultry and pig production, has introduced a limit to the number of pigs fattened in the country in order to limit emissions..[144] New factory farms can only open if other ones close down. However, this has led to an evasion of the Dutch livestock industry to other

142 Institut fur Ökologische Wirtschaftsforschung (2004): *Was kostet ein Schnitzel wirklich?*

143 Drucker A.G., Bergeron E.; Lemke U., Thury L.T. & Zarate A.V. (2006): *Identification and quantificationof subsidies relevant to the production of local and imported pig breed in Vietnam*. Tropical animal health and production 38: 305-322.

144 See: http://varkensrechten.nu

places like Eastern Europe where such limits do not exist.

No option: Intensification

Intensification as a mitigation approach is just a call for more of the same in policy terms: those who only have a hammer will only look for nails, as Dennis Meadows, an author of the Club of Rome's "Limits to Growth" put it. The new selection biotechnologies are increasing uniformity within even shorter time periods. They are aiming at higher selection intensity (e.g. DNA marker-assisted selection), shorter generation intervals (e.g. selection from embryo, not adult animals), more females than males in cattle and pig ('sexed semen'), and replication of the same animals (clones).

Such livestock biotechnologies are likely to lead to a faster increase in genetic uniformity, more market power and dependency on a few genetics corporations, more disease problems, more demands for subsidies, more pressure on animal welfare, environmental pollution, and more climate change, in sum, more of the problems that are already now an implicit part of the production system.

Some of the emissions can be captured in factory farms; biogas can be used to produce energy. CDM financing is available and used in dozens of registered projects in Brazil, Mexico, The Philippines, among others.[145] Certified reduced emissions of methane from factory farms are, however, greenwashing industrial livestock production. Carbon dioxide and nitrous oxide emissions persist, as do all other environmental, economic and social problems. More factory farms continue to create more problems. A partial solution, reducing methane emissions, is likely to trade off other climate, biodiversity, poverty goals.

Risky and far away options: Nitrification inhibitors, rumen microbial ecology, methanogen genomics and methane vaccine

This list of research topics has been presented by a publicly funded 25 mio NZD (11 mio Euro) research consortium led by New Zealand industry.[146] Around half of New Zealand's emissions stem from livestock, and agriculture provides half of New Zealand's export earnings.

With regard to nitrous oxide, experiments with nitrification inhibitors were made, and such agents are commercially available. However, they are far from being affordable, far from being efficient and far from being practical.

Ruminant livestock co-evolved together with grass land, and methanogens, the single cell organisms in their rumen that digest roughage, belong to the least understood group of microorganisms (Archae). As the New Zealand research consortium put it: to change enteric fermentation would mean to reverse 80-90 million years of evolution.

Conclusions

The vast majority of agricultural emissions are due to industrial livestock production in which cattle is fed on grain (and potentially competing with people) instead of roughage, and increased the "productivity" of poultry, pig and cattle to a point where their genetics are depleted, their health often depends on "biosecurity" and antibiotics, and their welfare is reduced to a state that is unacceptable to most citizens. Their numbers are far too many to keep the climate cool and citizens healthy, as 1 billion people are obese. Grasslands that are a major carbon sink and have evolved to co-exist with livestock may be turned into cropland for more feed for ever more livestock. Changing the bacteria that help turning grass into food within the ruminants' stomach will not reduce the numbers of cattle, the too high meat and milk consumption, the destruction of grassland as well as other carbon sinks for more feed production. Deleting - on average - between half and three quarters of the animal products from Northern diets is the imperative, not an option.[147]

145 see http://cdm.unfccc.int/Statistics/index.html

146 Clark H., Aspin M. & Montgomery H. (2008): *Industry and Government strategies for reducing methane and nitrous oxide emissions from New Zealand agriculture.* Presentation at "Livestock and global climate Change" conference", Tunisia, 17-20.5.2008; British Society of Animal Science.

147 Compassion in World Farming (2008): *Global warning: Climate change & farm animal welfare.* Summary report.

8. Conclusions

We risk paradigm maintenance. Current proposals for response to climate change seek to maintain current power structures and basically amount to business as usual. This must change.

The destruction of ecosystems continues, reducing their resilience to the stresses of climate change and converting them to GHG emitters. The failure to recognise the land rights and institute agrarian reform is breaking the relationship between local communities and their land, and leading to the further loss of cultural knowledge of critical value to us all.

Current proposed solutions offer only a reductionist approach to the complexities of climate change, converting every issue to greenhouse gas measurements. Most governments and institutions choose to rely on markets to guide action and propose that agriculture should be included in carbon trading. However, market policy failures are likely to result in subprime carbon markets.

Carbon markets also allow Annex1 countries to evade their own obligations and to reduce their emissions and their consumption of energy. This failure to assume responsibility damages prospects for cooperation and encourages cynicism. All this is likely to result in the collective failure to address climate change.

Until there is a genuine collective commitment to change, market mechanisms are more likely to exacerbate than solve the problem. The Clean Development Mechanism (CDM) and offsets must not be extended to agriculture.[148] Any proposal to extend REDD or REDD-plus mechanisms to agriculture is premature and amounts to a policy failure. Similarly, payments for environmental services in agriculture must not be allowed to become a means for donors, both public and private, to avoid real action. Furthermore, to include soils in carbon trading would stimulate the search for techno-fixes such as biochar or no-till agriculture,, rather than promoting any real attempt to carry out the soil research and restoration that is so urgently needed. We therefore question the effectiveness of any market mechanism in addressing climate change. Carbon trading should be suspended.

We need far deeper understanding of ecosystem functions and their multiple and interactive benefits. For this we need to recognise the multi-functional nature of agriculture. We should cease to undermine and instead support small-scale farming within an ecosystem approach. We need to place small farmers, indigenous peoples and local communities at the heart of policy-making.

We need local production for local markets, and a far broader and richer concept of productivity. For all these we need coherent government policies, not market mechanisms.

There are many policy changes that could have an immediate positive impact. Local communities need agrarian reform, security of land tenure and recognition of their collective/common rights to seed, land, water and soil. Indigenous peoples and small farmer movements are calling for this as fundamental to them continuing to perform their vital and often disregarded roles in protecting biodiversity. Researchers need to be able to share information and build insights, without being blocked by patent barriers and confidential business information claims. Funding needs to be directed to shared and farmer-centered research.

Above all we need government commitments and policies to support land reform and small-scale agriculture.

Agriculture and climate change:

Real problems, false solutions

Preliminary report by Grupo de Reflexion Rural, Biofuelwatch, EcoNexus and NOAH - Friends of the Earth Denmark, June 2009

http://www.econexus.org

148 CDM is already applied to pig and poultry factory farms.